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AERODYNAMIC HEATING COMPUTATIONS FOR PROJECTILES - VOL. I: IN-DEPTH HEAT CONDUCTION MODIFICATIONS TO THE ABRES SHAPE CHANGE CODE (BRLASCC)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The BRL has recently applied the ABRES Shape Change Code (ASCC80) to predict the unsteady thermal response of high velocity projectile nose configurations due to aerodynamic heating. The initial application of the ASCC80 code revealed several deficiencies as applied to slender shapes of interest for Army shell. This report describes the modifications carried out that improve the capabilities of the code to address problems for Army shell. Test cases and detailed instructions are provided which describe the input data required to run the code.		

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SECTION 1

INTRODUCTION

This report documents modifications and additions incorporated into the ABRES Shape Change Code (ASCC), originally developed under the Passive Nosetip Technology (PANT II) program (Reference 1), and subsequently modified and improved as part of the Reentry Vehicle Technology (REV-TECH) program (References 2 and 3). In this document, ASCC77 denotes the original version of ASCC developed under PANT II, and the current version of ASCC is referred to as ASCC80.

The overall objectives of the Aerodynamic Heating Computations for Projectiles program were threefold:

1. Modify the in-depth heat conduction package to improve ASCC's capabilities to handle slender multimaterial configurations
2. Extend the developments of planar ASCC modifications to predict heating of swept fin configurations to include: (a) turbulent flow on swept wings; (b) 2-D shock shape; and (c) improved in-depth heat conduction routines
3. Develop an interactive computational grid developing routine to simplify the procedure for inputting body configurations and developing computational grids

The modifications made to ASCC80 covering the first objective are documented in Volume I of this report. Changes made to ASCC80 covering

Objectives 2 and 3 are documented in Volumes II and III, respectively. In this document, the updated ASC code is referred to as BRLASCC.

BRLASCC includes all the modifications and improved capabilities made to ASCC under the previously mentioned programs and the following additional modifications:

- Body points which are positioned behind the origin of rays now have their rays perpendicular to the axis of symmetry, rather than emanating from the single origin. This extends the code applicability and accuracy for more slender nosetips, precluding excessive "skewing" of the mesh.
- The user can now vary the implicit grid thickness from ray to ray
- The interface modeling between different materials has been improved, particularly in the explicit grid, so that material properties used in the finite-difference conduction equations are utilized more accurately
- The user may now input latent heat of fusion for melting materials and BRLASCC will account for this energy during melting in the in-depth conduction solution
- The thermal resistance in the finite-difference conduction equations for the implicit and explicit grid have been modified to include contact resistances, which will be input by the user
- Up to six materials may now be input with up to five allowable interfaces along each ray within the implicit grid
- The common blocks have been restructured to allow individual users to easily identify and specify implicit and explicit grid parameters and recompile the code when necessary using the VAX Fortran "INCLUDE" statement

Technical discussion of the BRLASCC modifications, including rationale is presented in Section 2. Section 3 is devoted to a discussion of input and output. For user convenience, a complete set of input instructions is included. The user is encouraged to refer to Reference 2 for contrast of the input requirements.

SECTION 2

TECHNICAL DISCUSSION

Significant modifications and improvements have been incorporated in ASCC80 to generate BRLASCC. As stated in the introduction, the changes were aimed largely at improving ASCC's capabilities to handle the longer, more slender multimaterial configurations of interest to the U.S. Army Ballistic Research Laboratory. BRLASCC includes the following improvements: (1) accommodation of the entire projectile configuration by removing difficulties which result from extreme skewness of the implicit rays with the surface, (2) improved thermal resistance modeling, including the inclusion of contact resistance to the finite-difference conduction equations, (3) improved in-depth modeling by inclusion of latent heat of fusion, (4) increased capability to handle up to six different materials and allowing up to five interfaces on a ray within the implicit layer, (5) restructured common blocks, allowing the user flexibility for modifying the array sizes which determine the limits for the implicit and explicit grids. A discussion of these modifications is presented in Sections 2.1 through 2.5.

2.1 ACCOMMODATION OF THE ENTIRE PROJECTILE CONFIGURATION

ASCC80 utilizes dual, overlapping, orthogonal coordinate systems composed of the following: (a) moving body-oriented coordinate system, (s,r,γ), which extends over the heated surface layer, and (b) a fixed cylindrical coordinate system, (x,y,γ), extending over the entire

computational domain (Figure 2-1). Different finite difference equations are used in each region: implicit in (a) and explicit in (b). Therefore, the moving coordinate system is referred to as the implicit grid or surface layer, and the fixed coordinate system is referred to as the explicit grid. The major difficulty associated with the use of this gridding scheme is the use of a single origin of rays for the implicit grid. This procedure was originally developed and validated for nosetip problems, however two potential computational problems arise in the conduction solution when used for the prediction of more slender vehicle configurations such as nosetip and heatshield.

The first problem pertains to the placement of the origin of rays, OX. A basic assumption in the formulation of the finite-difference equations for the implicit layer is that the rays be as nearly ortho-normal to the surface as possible. ASCC contains approximate corrections to account for small

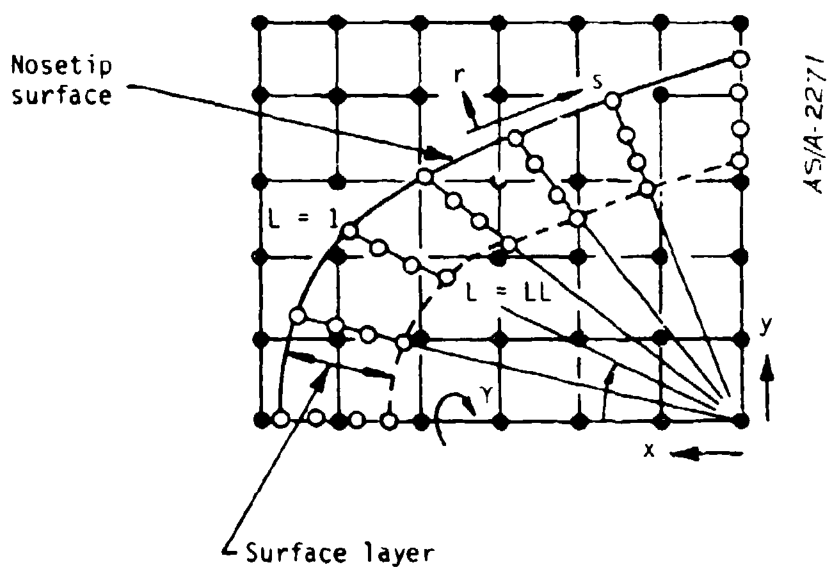


Figure 2-1. In-Depth Conduction Coordinate System and Finite-Difference Grid

nonorthogonalities, however these corrections are inadequate for cases where deviation from the assumption of orthogonality is significant. On long, slender configurations it is impossible to meet this criterion. If OX is placed near the nosetip, the implicit layer becomes so thin and distorted on the heatshield that the assumption of near orthogonality is invalid. If OX is placed far back on the frustum, the surface layer near the tangent point has the potential of forming a cusp in the implicit grid, causing instabilities in the conduction solution. This results in negative temperatures and negative time steps which halt further execution of the code. By judicious placement of the origin OX and using proper mesh size for the explicit grid, reliable predictions can be made on the entire configuration. However, the computational speed is slow due to small time steps required by the explicit procedure stability criterion, which is affected by the smaller spatial mesh size.

The second problem arises due to the limitations placed on the input of implicit layer thickness along the rays. This problem is illustrated in Figure 2-2 and is caused by the constant thickness of the implicit layer along each ray. Surface Layer 1 of Figure 2-2 uses a thick layer which strongly skews the back of the implicit mesh near the origin, resulting in the cusp. This distortion of the mesh can cause numerical instabilities resulting in

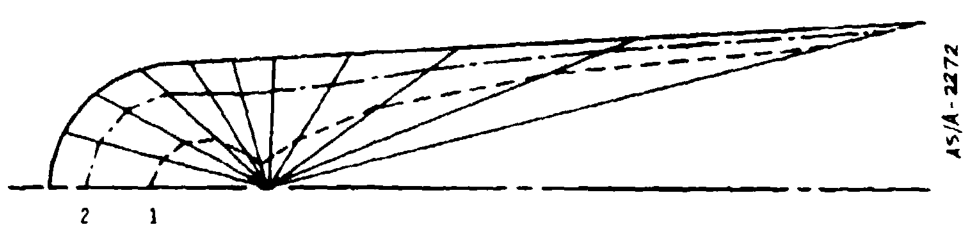
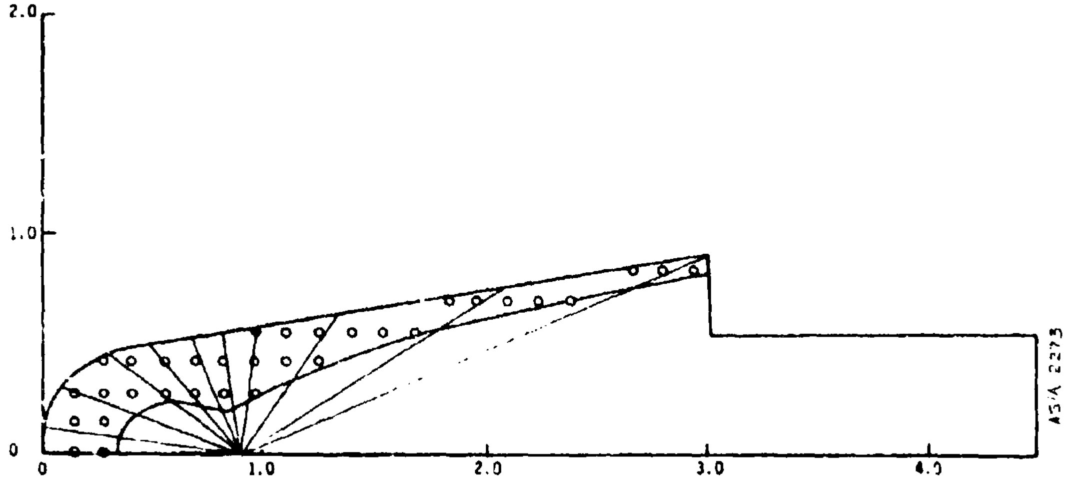


Figure 2-2. Skewing of Implicit Grid Resulting From Thick Surface Layer

negative temperatures. Surface Layer 2 uses a thinner layer, and the distortion is nearly eliminated in the vicinity of the origin; however, the layer's thickness with respect to the explicit grid y-direction is very small, requiring small explicit mesh spacing and resulting in small time step sizes.

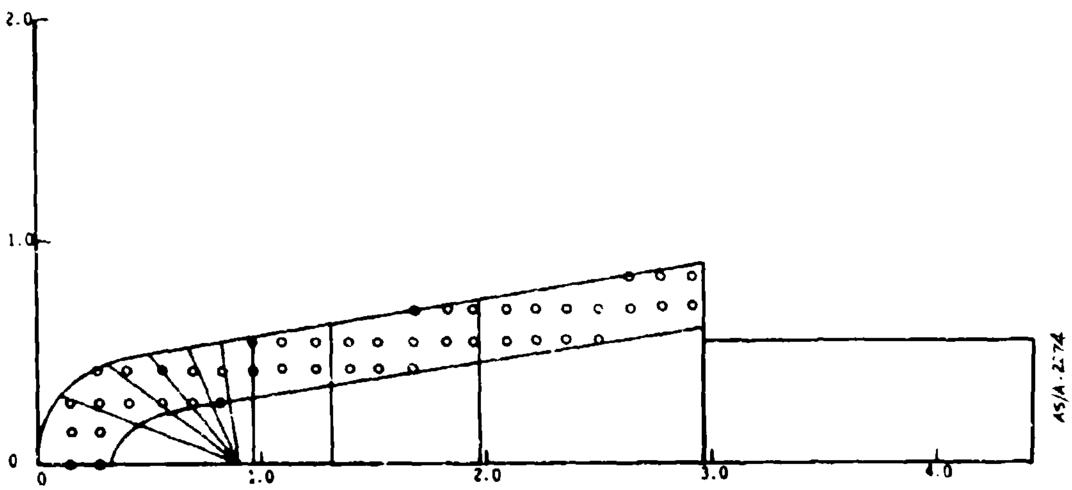
The limitations on the location of the origin of rays and the implicit layer thickness poses restrictions on the mesh size of the explicit grid, and consequently the length of the vehicle which can be accurately modeled. To alleviate these difficulties in BRLASCC, two modifications were made. First, the old "radial" implicit gridding scheme extant in ASCC80 has been converted to a dual system which is "radial" in the nosetip region and "cylindrical" in the afterbody region. The difference between the old and new grid systems is illustrated in Figures 2-3 and 2-4. For body points which lie behind the origin of rays, the rays are now perpendicular to the axis of symmetry instead of originating at OX. This will allow the user to use the ray system for shape change with in-depth conduction in the nose region and will prevent the severe nonorthogonality with the surface at distances downstream of the nosetip.

Secondly, the current requirement that the implicit grid thickness be constant along each ray has been removed. Instead of inputting a table of implicit grid node spacing, the code now accepts a table of normalized node spacing and a table of implicit layer total thickness along each ray. This will allow the user to use thicker and better contoured implicit layers as seen in Figure 2-4 and avoid the skewing shown in Figure 2-2. On the frustum, many more explicit nodes fall within the implicit layer giving better definition to the explicit boundary conditions. The skewing near OX is eliminated through proper use of the implicit grid thickness table. Figure 2-5 compares in-depth temperature predictions made using ASCC80 and



(a) Conduction Grid Using the Previous ASCC Scheme

Figure 2-3. Conduction Grid Using Current ASCC80 Scheme



(b) Conduction Grid Using the Modified ASCC Scheme

Figure 2-4. Conduction Grid Using BRLASCC Scheme

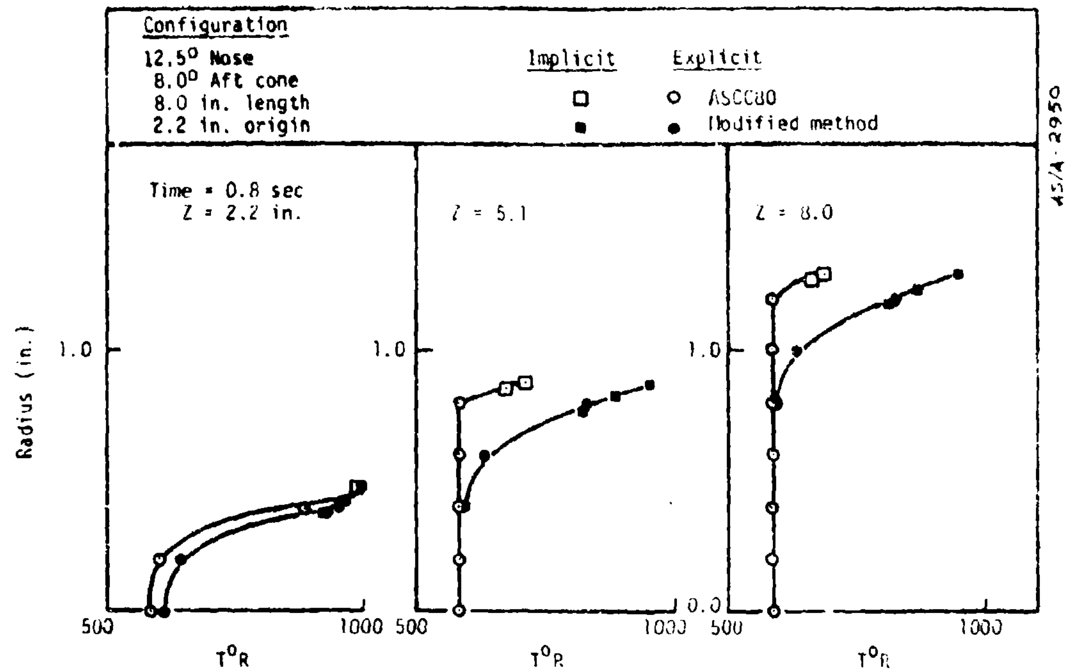


Figure 2-5. Comparison of In-Depth Temperature Profiles Predicted With ASCC80 and BRLASCC Gridding Schemes

BRLASCC gridding schemes. As can be seen, BRLASCC provides much greater coupling between the explicit (in-depth) temperatures and the implicit (surface layer) temperatures.

2.2 IMPROVED THERMAL RESISTANCE MODELING

The conduction package in ASCC allows several material interfaces to be included in the analysis. Each explicit grid point (node) and implicit grid point (nodlet) is flagged with an integer denoting the material number of that grid point. ASCC80 uses a simple average of the material property values of the node materials to model the properties of each finite-difference cell and does not account for the contact resistance at material interfaces. When adjacent materials have very dissimilar physical properties this assumption can cause substantial smoothing and loss of accuracy. In addition, ASCC80 contains no provision for the inclusion of contact resistance between

materials. BRLASCC overcomes these problems by calculating the proper thermal resistance between nodes and keeps track of interface locations in both the implicit and explicit grids and includes contact resistance if input by the user.

2.2.1 Implicit Grid Modifications

The conduction equation in the moving orthogonal coordinate system (implicit grid) under the axisymmetric assumption ($\partial/\partial r = 0$) is:

$$\rho C_p \frac{\partial T}{\partial t} = \frac{1}{r_b\,(1 + r/r_c)} \left\{ \frac{\partial}{\partial s} \left[\left(\frac{r_b}{1 + r/r_c} \right) \kappa \, \frac{\partial T}{\partial S} \right] + \frac{\partial}{\partial r} \left[r_b (1 + r/r_c)\ \kappa \ \frac{\partial T}{\partial r} \right] \right\} \qquad (1)$$

$$+ \ \rho C_p \ \dot{n} \ \frac{\partial T}{\partial r}$$

where

C_p = specific heat

r_0 = body circumferential radius of curvature

r_b = r_0 + $r \cdot \cos(\theta)$

r_c = local streamwise radius of curvature

κ = thermal conductivity

ρ = density

$\dot{n}$ = surface normal recession rate, $\dot{n} = -\dot{r}$

T = temperature

t = time

θ = angle between normal to local surface and axis of symmetry

s = streamwise distance along body

r = distance normal to body surface at s, measured from the surface

where r_b is the body radius of curvature in a plane perpendicular to the axis, r_c is the local surface streamwise radius of curvature, and θ is the surface inclination with respect to the axis.

The finite-difference equation for the implicit grid in ASCC80 is:

$$
\begin{aligned}
&\delta_{L+1} \cos^2\theta \frac{(\rho C_p)_{L+1/2}}{\Delta\tau} (T'_L + T'_{L+1} - T_L - T_{L+1}) \\
&\qquad = 2\delta_{L+1} \cos^2\theta \dot{q}_s + \dot{q}_{lc} + 2(\rho C_p)_{L+1/2} \cos\theta\, \dot{s}' (T'_{L+1} - T'_L) \\
&\qquad - \frac{[r_b(1+r/r_c)]_{L'}}{[r_b(1+r/r_c)]_{L'+1/2}}\, k_L \left(\frac{T'_{L-1} - T'_L}{\delta_L} + \frac{T'_L - T'_{L+1}}{\delta_{L+1}} \right) \\
&\qquad - \frac{[r_b(1+r/r_c)]_{L'+1}}{[r_b(1+r/r_c)]_{L'+1/2}}\, k_{L+1} \left(\frac{T'_L - T'_{L+1}}{\delta_{L+1}} + \frac{T'_{L+1} - T'_{L+2}}{\delta_{L+1}} \right)
\end{aligned}
\tag{2}
$$

where the superscript prime indicates the quantities evaluated at the new time, $\dot{q}_{lc}$ is the lateral conduction correction term associated with nonorthogonal rays, and $\dot{q}_s$ is the lateral diffusion term. In the formulation of the finite-difference expression, it is assumed that the lateral diffusion term is small compared with the normal diffusion term and therefore may be evaluated in terms of the old temperatures and appears as a "source" term in the equation.

The finite-difference equation for the implicit grid has been modified and appears in BRLASCC as:

$$\delta_{L+1} \cos^2\theta \frac{(\rho C_p)_{L+1/2}}{\Delta\tau} (T'_L + T'_{L+1} - T_L - T_{L+1}) = 2\delta_{L+1} \cos^2\theta\, \dot{q}_s$$

$$+ \dot{q}_{1c} + 2(\rho C_p)_{L+1/2} \cos\theta\, \dot{s}'(T'_{L+1} - T'_L) + \frac{[r_b(1+r/r_c)]_{L'}}{[r_b(1+r/r_c)]_{L'+1/2}}$$

$$2\left\{\left(\frac{\delta_L}{\delta_L + \delta_{L+1}}\right)\left(\frac{1}{R_1}\right)\left(T'_{L-1} - T'_L\right) + \left(\frac{\delta_{L+1}}{\delta_L + \delta_{L+1}}\right)\left(\frac{1}{R_2}\right)\left(T'_L - T'_{L+1}\right)\right\} \quad (3)$$

$$- \frac{[r_b(1+r/r_c)]_{L'}}{[r_b(1+r/r_c)]_{L'+1/2}}\; 2\left\{\left(\frac{\delta_{L+1}}{\delta_{L+1} + \delta_{L+2}}\right)\left(\frac{1}{R_2}\right)\left(T'_L - T'_{L+1}\right)\right.$$

$$\left. + \left(\frac{\delta_{L+2}}{\delta_{L+1} + \delta_{L+2}}\right)\left(\frac{1}{R_3}\right)\left(T'_{L+1} - T'_{L+2}\right)\right\}$$

where the thermal resistances are given as:

$$R_1 \equiv \left[\frac{\delta_{I_1}}{k_{L-1}} + \frac{\delta_L - \delta_{I_1}}{k_L} + \frac{1}{h_{contact}}\right]; \quad \delta_{I_1} \equiv \text{distance from nodlet L-1 to interface}$$

$$R_2 \equiv \left[\frac{\delta_{I_2}}{k_L} + \frac{\delta_{L+1} - \delta_{I_2}}{k_{L+1}} + \frac{1}{h_{contact}}\right]; \quad \delta_{I_2} \equiv \text{distance from nodlet L to interface}$$

$$R_3 \equiv \left[\frac{\delta_{I_3}}{k_{L+1}} + \frac{\delta_{L+2} - \delta_{I_3}}{k_{L+2}} + \frac{1}{h_{contact}}\right]; \quad \delta_{I_3} \equiv \text{distance from nodlet L+1 to interface}$$

Note that instead of the simple average of thermal conductivity used in ASCC80, BRLASCC calculates the thermal resistance through each material as a function of conduction path length and thermal conductivity, and includes contact resistance.

2.2.2 Explicit Grid Modifications

The conduction equation in the fixed cylindrical coordinate system (explicit grid) is:

$$\rho C_p \frac{\partial T}{\partial t} = \frac{\partial}{\partial x}\left(k \frac{\partial T}{\partial x}\right) + \frac{1}{y}\frac{\partial}{\partial y}\left(yk \frac{\partial T}{\partial y}\right) \tag{4}$$

The finite-difference equation for the explicit grid in ASCC80 is:

$$\begin{aligned}(\rho C_p)_{I,J} \frac{T'_{I,J} - T_{I,J}}{\Delta\tau} = {} & \frac{2}{y_J(y_{J+1} - y_{J-1})}\left[y_{J-1/2} \frac{1}{R_{I,J-1/2}} (T_{I,J-1} - T_{I,J}) \right. \\ & \left. - y_{J+1/2} \frac{1}{R_{I,J+1/2}} (T_{I,J} - T_{I,J+1})\right] + \frac{2}{(x_{I+1} - x_{I-1})} \\ & \left[\frac{1}{R_{I-1/2,J}} (T_{I-1,J} - T_{I,J}) - \frac{1}{R_{I+1/2,J}} (T_{I,J} - T_{I+1,J})\right]\end{aligned} \tag{5}$$

where again the superscript prime indicates the quantity to be evaluated at the new time. The thermal resistance is given as:

$$R_{I+1/2,J} = \frac{1}{2}\left(\frac{1}{k_{I,J}} + \frac{1}{k_{I+1,J}}\right)(x_{I+J} - x_I) \tag{6}$$

The thermal resistance term has been modified in BRLASCC and appears as:

$$R_{I,J-1/2} = \left[\frac{\delta_y - y_{J-1}}{k_{J-1}} + \frac{y_J - \delta_y}{k_J} + \frac{1}{h_{contact}}\right]; \ \delta_y \equiv \text{distance from } y_{J-1} \text{ to interface in y-direction} \quad (7)$$

$$R_{I+1/2,J} = \left[\frac{x_{I+1} - \delta_x}{k_{I+1}} + \frac{\delta_x - x_I}{k_I} + \frac{1}{h_{contact}}\right]; \ \delta_x \equiv \text{distance from } x_I \text{ to interface in x-direction} \quad (8)$$

As in the expression for the implicit conduction equation, the thermal resistance calculation has been modified to use the appropriate material thermal conductivity and conduction path length and includes contact resistance.

2.3 LATENT HEAT OF FUSION

A model to account for the latent heat of fusion during in-depth melting of a material has been included in BRLASCC. The energy storage terms, ρC_p, are affected in both the implicit and explicit formulations of the conduction equation. The energy required to melt a material may now be input to the code by the user (see Section 3, Input Table 6 -- Material Properties) and is included in the sensible enthalpy calculation for the material tables. A saw-tooth function of specific heat versus temperature is constructed from user input of latent heat of fusion (ΔL), melt temperature, specific heat of the solid at melt temperature, specific heat of the liquid at melt temperature, and the temperature difference over which the user would like melt to occur (ΔT_m). The integration of Cp over ΔT results in the proper sensible enthalpy, as shown in Figure 2-6.

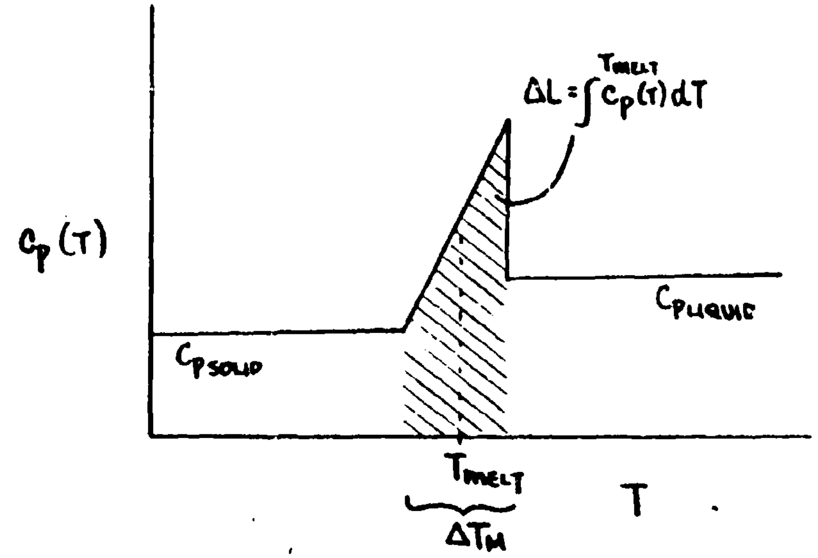


Figure 2-6. Saw-Tooth Function of Specific Heat Versus Temperature for a Melting Material

An analytical solution is available from Carslaw and Jaeger (Reference 4) for the melting of a semi-infinite solid without melt removal. In this solution the transient temperature distribution and position of melt front are given as a function of time, material properties, and initial condition. This solution was used as a reference to check against the BRLASCC solution. Three cases were run:

- Implicit layer thickness of 1 inch; uniform implicit nodlet spacing of 0.14286 inch; uniform explict node spacing of 0.50 inch
- Implicit layer thickness of 1 inch; uniform implicit nodlet spacing of 0.07143 inch (half of case 1); uniform explicit node spacing of 0.50 inch

- Implicit layer thickness of 1 inch; uniform implicit nodlet spacing of 0.07143 inch; uniform explicit node spacing of 0.25 inch (half of case 1)

The material properties used in the analysis are given in Table 2-1. The Carslaw and Jaeger solution and BRLASCC solutions are compared in Figures 2-7 and 2-8 for temperature distribution at 200 seconds and melt front position versus time, respectively. The results show good agreement between BRLASCC and the analytical solution. However, it is clear from the figures that the accuracy of the solution is mesh size dependent; halving the mesh spacing nearly halves the error. The user must exercise good judgment in mesh spacing when generating solutions involving in-depth melting.

The user must also note that the model for latent heat of fusion is not adequate for surface melting since melt removal coupled with shape change is not modeled. The surface energy balance would be in error as melt occurs, resulting in incorrect shaping, and these errors would grow in time.

Table 2-1. Melting of a Semi-Infinite Solid -- Material Properties

Material Properties	Solid	Liquid
k (Btu/sec-ft-°R)	7.56×10^{-3}	2.10×10^{-3}
α (ft^2/sec)	1.208×10^{-4}	2.222×10^{-5}
Cp (Btu/lbm-°R)	0.128	0.1932
ΔL = 117 Btu/lbm	Latent heat of fusion	
T_0 = 500°F	Initial solid temperature	
T_1 = 2,800°F	Melt temperature	
V = 4,000°F	Surface temperature	

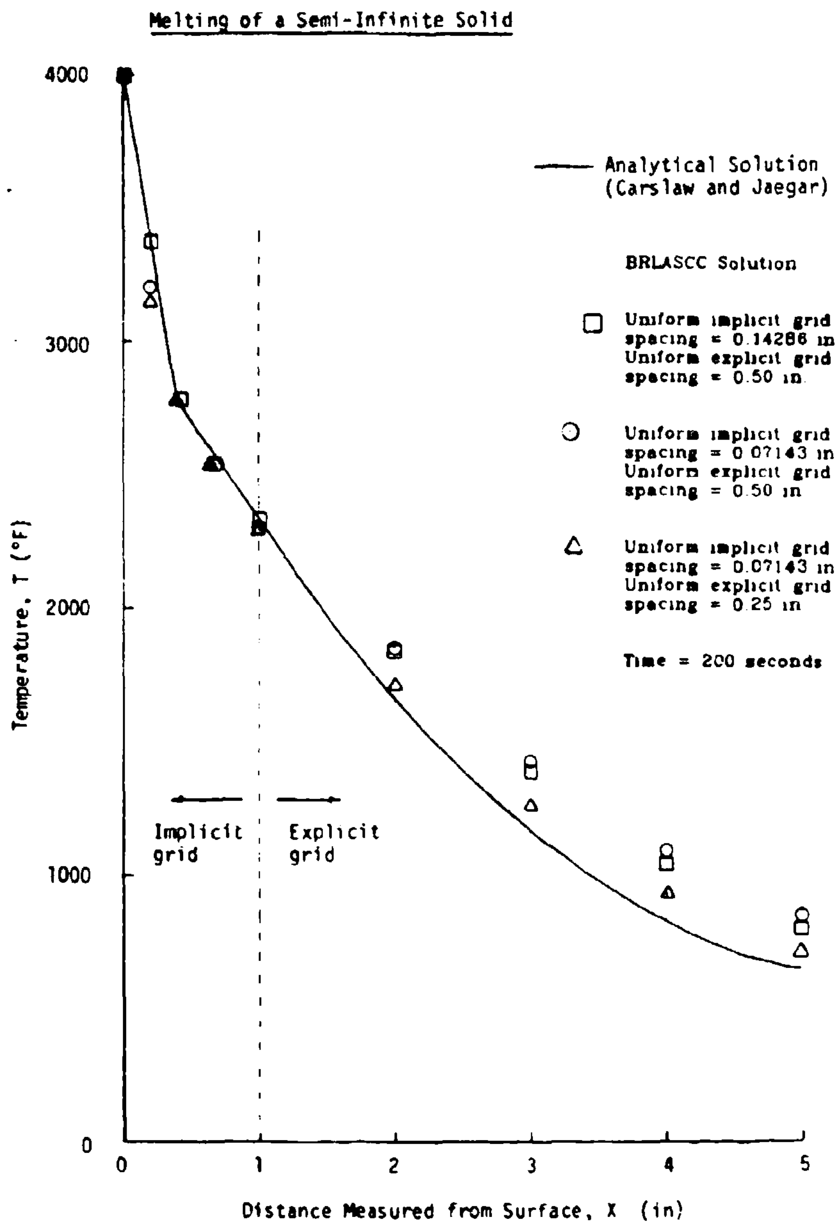


Figure 2-7. Comparison of In-Depth Temperature Distribution for a Melting Solid Predicted by Carslaw and Jaeger and BRLASCC

Melting of a Semi-Infinite Solid

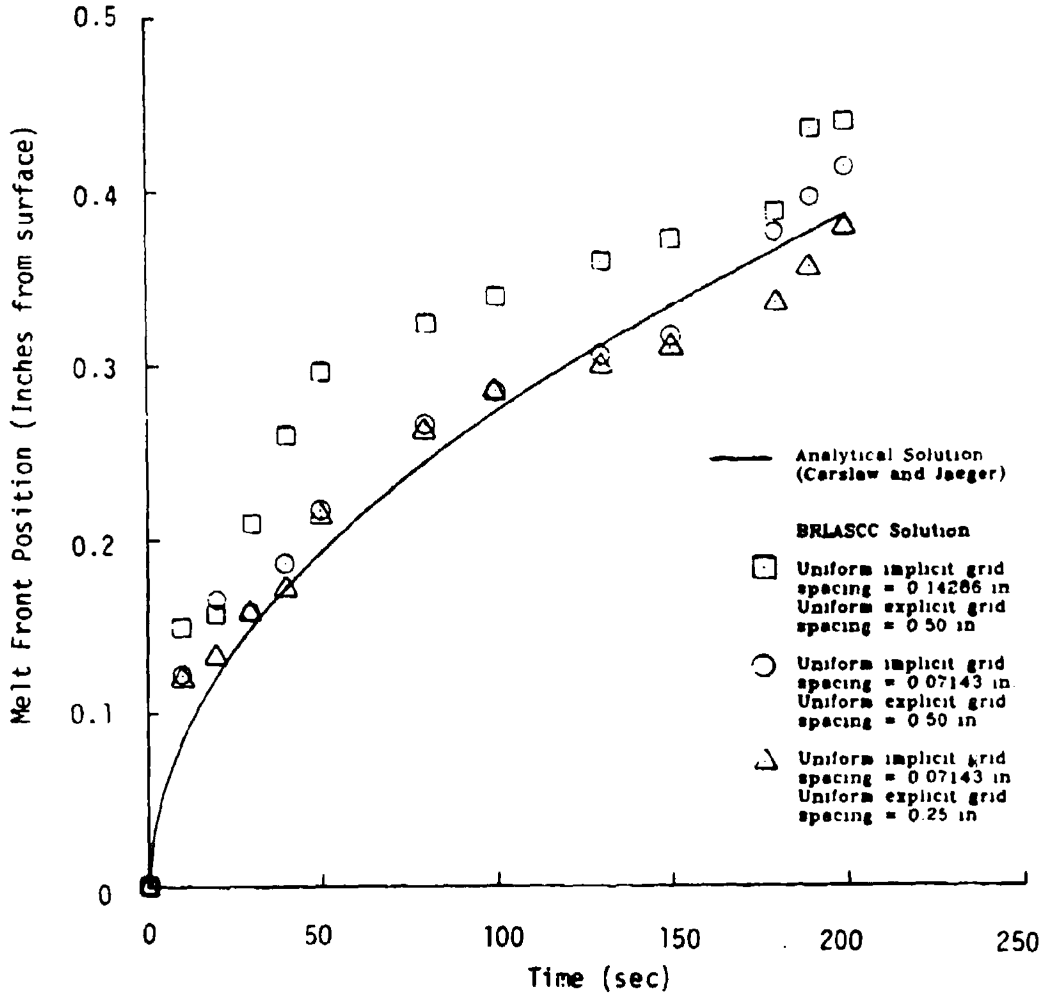


Figure 2-8. Comparison of Melt Front Location for a Melting Solid Predicted by Carslaw and Jaeger and BRLASCC

2.4 MULTIPLE MATERIAL HANDLING

As the application of the ASC code broadens, more complex internal geometries are being considered. ASCC80 contains an easily used general shape input option that allows the description of complex internal geometries with up to four materials, and allowing two interfaces on each ray within the implicit layer. BRLASCC has been updated to allow the input of up to six materials and allows up to five interfaces on each ray within the implicit layer. This will facilitate the calculation of complex in-depth configurations.

2.5 FLEXIBLE GRID ARRAY SIZES

The size of the arrays used for the thermal conduction grids is often restrictive for complete configurations of interest. This is especially true of the number of y-values in the explicit grid. Increasing the allowed grid sizes is simply a matter of increasing the dimensions of the arrays. Since BRLASCC makes extensive use of the VAX Fortran INCLUDE statement, this change only requires modifications to the common blocks containing the necessary arrays and a recompilation of the code. It should be noted that redimensioning of those arrays used in the restart routine DATFIL would be necessary to preserve the restart capability.

One difficulty with increasing the dimensions of the arrays will be the core limitations of the particular machine being used. For this reason, the arrays to be redimensioned have been regrouped in their common blocks and INCLUDE files to facilitate changing the grid array sizes whenever necessary. These groupings of common blocks are commented for user convenience. The array sizes have not been changed between ASCC80 and BRLASCC; this is left to the discretion of the user. A sample of the regrouped and commented common blocks for use with the INCLUDE statement is shown in Table 2-2.

Table 2-2. A Sample of Commented Common Blocks

```
C
C***********************************************************************
C      THE FOLLOWING COMMON BLOCKS CONTAIN CONSTANT VARIABLES WHOSE
C      VALUES WILL NOT CHANGE DURING EXECUTION
C***********************************************************************
C
      COMMON  /CONST/
     * ALMAX,       ALMIN,       DEXMIN,       DLTMIN,       DLTRAN,
     * DOX,         DSHANG,      FMO,          GFHI,         HJNCTN,
     * HSCF,        HSCI,        HTJF,         HTJI,         HZEROT,
     * OX,          OY,          PR,
     * RBAS,        RNI,         RPHI,         RSIDE,        RX,
     * RZ,          SPHTC,       STRD,         THETA,        THETAC,
     * TRNTIM,      VLN,         WT,           XCG,          ZMAX,
     * ZMAXTJ,      ZSIDE1,      ZSTAG1,
     * AM(30),      REM(30),
     * RECORD(36)
     * PRTBL(60),   'PRTBL(60),
     * TIMUSR(250)
C
      COMMON  /CONSTI/
     * IATM,        IATMS,       IBRUPT,       ICARB,        IDRCTN,
     * IFACE,       IFLG09,      IHMAX,        IL,           INDATM,
     * IMOD,        INPUT,       IPMAX,
     * IPRFLG,      IPRNT,       IRON,         IRSTRT,       ISHFLG,
     * ISS,         JL,          LG,           LL,           MATN,
     * MLAYRS,      NAM,         NCL,
     * NIF,         NLAYRS,      NOHEAL,
     * NOSLO,       NPRTBL,      NREYCR,       NSHTBL,       NTFIX,
     * NTIMT,       NTMUSR
C
C-----------------------------------------------------------------------
C     DIMENSIONED FOR 15 IMPLICIT NODLETS, 50 SURFACE POINTS,
C     X(60) BY Y(25) EXPLICIT NODES, AND 100 ENTRIES IN GENERAL
C                  INTERFACE TABLES
C-----------------------------------------------------------------------
C
      COMMON /CONGRD/
     * DSMOV,       DTDROP,      OXN,
     * DELN(15),
     * Y(25),       YDIF(25),
     * DEL(50),     XINIT(50),   YINIT(50),
     * X(60),       XDIF(60),
     * ZIS(100),    RIS(100),
     * DMIN(60,25),
     * IDROP,       IMOVE,
     * NBS(100),
     * NMAT(60,25)
```

Table 2-2. A Sample of Commented Common Blocks (Concluded)

```
C
C**********************************************************************
C      THE FOLLOWING COMMON BLOCKS CONTAIN VARIABLES WHOSE VALUES
C      WILL CHANGE DURING THE EXECUTION
C**********************************************************************
C
      COMMON  /ENVR/
     * ALTINF,     AMACH,      A1,         A2,         CDNT,
     * DEN,        DUDZ,       EMWT2,      EMW2,       EMW1,
     * E2,         GAM1,       GAM2,       HETAUG,     HT2,
     * H1,         H2,         PT2,        P1,         P2,
     * REYCR,      RN,         ROT2,       RO1,        RO2,
     * SSONIC,     STRAN,      TSTAGP,     TT2,        T1,
     * T2,         UR1,        VIST2,      VIS2,       V1,
     * V2,
     * IESTAT,     IEXX,       INOSE,      KSHOLD,     LCT,
     * LTT,        NOSTRN,     NPGENV,     NT,         NTS,
     * NTT
C
C----------------------------------------------------------------------
C     DIMENSIONED FOR 50 SURFACE POINTS, 5 MATERIAL INTERFACES,
C     AND 15 IMPLICIT NODLETS
C----------------------------------------------------------------------
C
      COMMON /RECSA/
     * BPSP(50),   CMDX(50),   CMFX(50),   DELKE(50),
     * DFIF(50),   DPART(50),  EFFK(50),   EMDOT(50),  FI(50),
     * FVW(50),    GKR(50),    HRSP(50),   PRESP(50),
     * RSP(50),    RSPNU(50),  RUCHSP(50), SDOT(50),   SDOTE(50),
     * SP(50),     SRAY(50),   TANFI(50),  THETSP(50), TSP(50),
     * VIMP(50),   ZSP(50),    ZSPNU(50),
     * BLEN(50,5), RI(50,5),   ZI(50,5),
     * IHI(38),    ILO(38),    IR(38),
     * NB(50,6),
     * IMAT(50,15)
```

SECTION 3

INPUT AND OUTPUT

The following section is a user's guide of the input requirements for the modified ABRES Shape Change Code (BRLASCC). The input has changed from ASCC80 in the following manner:

- On the first restart card, variable DOX has been added. When the automatic shifting of origin option is exercised, BRLASCC will shift the origin by DOX inches rather than OX inches as in ASCC80.
- In Input Table 3, the ASCC77 general body shape input option has been eliminated. All general shapes and multimaterial cases must be input with the ASCC80 general shape input methodology.
- In Input Table 3, variable implicit layer thickness on each ray is now an option. The user must specify the normalized spacing that will apply to every ray and the implicit layer thickness on each ray.
- In Input Table 6, material properties for melting materials is now an input option. Should the user wish to include in-depth melting of materials the user must specify the latent heat of fusion (XLATHT), melt temperature (TMELT), temperature difference over which melt is to occur (DTMELT), specific heat of the solid at TMELT (CPSOLD), and the specific heat of the liquid at TMELT (CPLIQD).

3.1 INPUT INSTRUCTIONS

The input to the code can be read from a disk file or data cards for an initial run, or from magnetic tape or disk for a restart run. The details of the input for each of these types of runs are described below. The basic input for an initial run consists of:

- Two restart information cards
- Three title cards
- Nine input tables

Not all nine of the input tables are required for every run. Each table is preceded by a single card containing the identifying table number.

For a restart run, only the restart information cards are required, and the rest of the data is read from magnetic tape or disk.

The following are FORTRAN I/O unit assignments.

Unit	Device Type	Purpose
1	Terminal (interactive) Disk file (batch)	Lists current environment number, time, and altitude.
5	Disk file (interactive/batch)	Input data
6	Disk file (interactive/batch) Printer (batch) Terminal (interactive)	Output data
14	Disk file (interactive/batch) Magnetic tape (interactive/batch)	Restart file
20	Disk file (interactive/batch)	For coupled trajectory option, trajectory scratch file

The following sections describe the restart information, title cards, and the nine input tables, respectively.

Restart Information

The "restart" cards are the first card set in the data deck. If the run is a restart, they are the only cards required. These cards tell the code

the environment number from which to begin the restart and what modifications should be made in the conduction grid. For an initial run, the IRSTRT field should be left blank. The BRLASCC code stores the contents of its common blocks on the restart file at the end of each cycle of environment and/or shape change calculation. All restart reading and/or writing is done on Logical Unit 14 and it should be assigned accordingly.

Two options allow modifications to the implicit conduction grid during a calculation. These modifications may be done automatically or by restarting the solution. The first option drops surface points from the grid and allows larger time steps. The second option shifts the origin of rays and interpolates for temperatures at the new implicit grid points. The modifications are done automatically by the code when the user specifies the proper values of IDROP, IMOVE, DOX, DTDROP, DSMOVE. They can be done manually by restarting the solution and specifying OXN and IPDRP.

The format for the restart cards is as follows.

Card No.	Columns	Format	Data	Units
1	1- 5	I5	IRSTRT -- ENVIRONMENT NO. to restart from	--
	6-10	I5	NTFIX -- ENVIRONMENT NO. to fix shape. This causes the shape to remain fixed subsequent to assigned environment number	--
*	11-15	I5	IDROP -- Flag to allow automatic dropping of surface points	--
			= 0 -- Surface points will not be dropped	
			= 1 -- Surface points will be dropped when the lateral conduction time step becomes less than DTDROP	

Card No.	Columns	Format	Data	Units
*	16-20	I5	IMOVE -- Flag to allow automatic shifting or origin of rays	--
			= 0 -- Origin of rays will not be shifted	
			= 1 -- Origin of rays will be shifted DOX inches when the implicit grid is less than DSMOV inches from origin	
	21-32	E12.5	OXN -- Z-coordinate for the new origin of rays during restart	Inch
*	33-44	E12.5	DOX -- Origin of rays will be shifted when needed by this amount; IMOVE = 1	Inch
*	45-56	E12.5	DSMOV -- See IMOVE	Inch
*	57-68	E12.5	DTDROP -- See IDROP	Sec

- - - - - - - - - - - - - - - - Regrid option only - - - - - - - - - - - - - - - -

(Read only if OXN ≠ 0.0)

Card No.	Columns	Format	Data	Units
*2	1-50	50I1	IPDRP(K) -- For K = 1, KLF (50 to a card), flag for dropping surface point	
			= 0 -- Retain point	
			= 1 -- Drop point	

Title Information

The next three cards contain title information in Columns 1 through 72. Contents of Columns 61 through 72 on Card 3 are printed on every page of the output.

INPUT TABLE 1. GENERAL PROGRAM CONSTANTS AND TIME INFORMATION

This table supplies the code with computation time information and program flags which indicate options to be subsequently read.

Card No.	Columns	Format	Data	Units
1	1- 2	I2	Enter 01 (table number)	--
2	3-14	E12.5	TI -- Initial time (for LG = -1 it corresponds to the initial conditions for trajectory calculations)	Sec
	15-26	E12.5	TF -- Final time	Sec
	27-38	E12.5	DLTMIN -- Minimum allowable time step. If negative, only user's specified time steps (DLTT) are used. A default value of 10^{-6} sec will be used if zero is entered. This default value is satisfactory in most cases; thus, the user can usually enter zero	Sec
3	1- 5	I5	LG -- Environment flag -1 -- Flight (internally computed trajectory, Table 2 not needed) Table 2 required: 1 -- Flight 2 -- Wind tunnel 3 -- Ballistic range 4 -- General 5 -- Arc heater	--
	6-10	I5	ISS -- Shape change flag 0 -- Shape change with transient in-depth conduction 1 -- Shape change with steady-state in-depth conduction 2 -- No shape change (boundary layer solution only)	--

INPUT TABLE 1. Continued

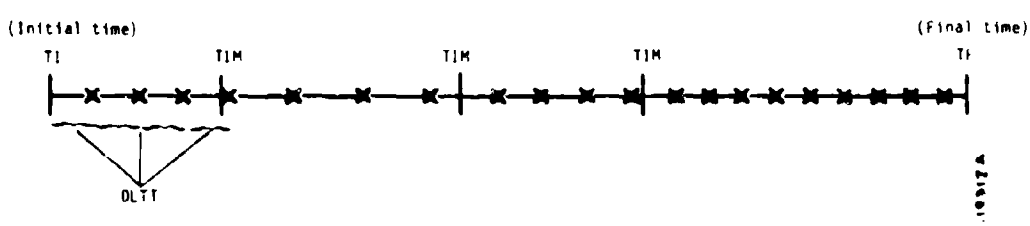
Card No.	Columns	Format	Data	Units
3	11-15	I5	IPRNT -- Output print flag	--
			0 -- Summary table only	
			1 -- Detailed output at body points	
			2 -- Detailed output at integration points	
			Positive IPRNT -- Output at user specified environment times only (DLTT)	
			Negative IPRNT -- Output at all environment times	
	16-20	I5	NREYCR -- Transition criteria flag	--
			1 -- Laminar flow (Table 04 not required)	
		Table 04 required	2 -- Critical momentum thickness Reynolds number versus edge Mach number	
			3 -- Critical stream length Reynolds number versus edge Mach number	
			4 -- Nosetip axial distance versus:	
			-- Altitude for LG = 1	
			-- Time for LG = 2, 3, 4, 5	
		Table 04 not required	5 -- Anderson nose criterion	
			$Re_\theta \left(\frac{k}{\theta}\frac{1}{\psi}\right)^{0.7} =$ 255 for onset; 215 for location	
			$\psi = T_w/T_e$	
			LORN cone criterion	
			6 -- Anderson nose criterion	
			$Re_\theta \left(\frac{k}{\theta}\frac{1}{\psi}\right)^{0.7} =$ 255 for onset; 215 for location	

INPUT TABLE 1. Continued

Card No.	Columns	Format	Data	Units
		Table 04 not required	$\psi = 0.1B' + [(0.9 + 0.1ICARB)(1 + 0.25B')(\rho_e/\rho_w)]$	
			LORN cone criterion	
			7 -- Fully turbulent	
3 (Continued)			Positive NREYCR -- Transitional heating	
			Negative NREYCR -- No transitional heating (abrupt transition)	
3	21-25	I5	IRON -- Body angle definition flag	--
			-1 -- Circle curve fit	
			0 -- Circle fit for laminar flow, angle averaging for turbulent flow with damping logic for negative curvature (recommended for shape change)	
			1 -- Angle averaging	
	26-30	I5	ICARB -- Carbon flag in PANT transition criterion (NREYCR = 6)	--
			0 -- Uses 0.9 factor in ψ calculation (recommended for carbon materials)	
			1 -- Uses 1.0 factor in ψ calculation	
*	31-35	I5	IATM -- Atmosphere-type flag for LG = 1	--
			1 -- Standard kwajalein atmosphere	
			2 -- U.S. standard atmosphere, 1962	
*	36-40	I5	IATMS -- Atmosphere-type flag for LG = -1	--
			1 -- No atmosphere 2 -- 1962 standard 3 -- 15 deg north annual 4 -- 30 deg north January 5 -- 30 deg north July 6 -- 45 deg north January 7 -- 45 deg north July 8 -- 45 deg north spring/fall 9 -- 60 deg north January 10 -- 60 deg north January (cold) 11 -- 60 deg north January (warm) 12 -- 60 deg north July 13 -- 75 deg north January	

INPUT TABLE 1. Continued

Card No.	Columns	Format	Data	Units
			14 -- 75 deg north January (cold) 15 -- 75 deg north January (warm) 16 -- 75 deg north July 17 -- Tonapah winter 18 -- Tonapah spring 19 -- Tonapah summer 20 -- Tonapah fall	
*3 (Continued)	41-45	I5	IMOD -- Nose shape modification. The code does not allow the surface angle between two adjacent points to exceed 89.5°. The user has the option to specify whether the point (I + 1) or (I - 1) is used to control the recession at point I. IMOD = 1 usually results in larger timesteps in severe erosion environments. 0 -- Use I and (I + 1) 1 -- Use I and (I - 1)	
4	1- 2	I2	Nonzero entry for the last card in the table	--
	3-14	E12.5	DLTT -- Environment time step (at the end of each interval new environment will be calculated)	Sec
	15-26	E12.5	TIM -- Time for change of DLTT	Sec
5	Same as Card 4 for various output intervals			
(etc.)				



\- - - - - - - - - - - - Trajectory calculation option only - - - - - - - - - - - -

(Read only if LG = -1)

INPUT TABLE 1. Concluded

Card No.	Columns	Format	Data	Units
*6	3-14	E12.5	HTJI -- Altitude at which trajectory calculations start	Ft
	15-26	E12.5	HSCI -- Altitude at which shape change calculations start (typically shape change should be limited to altitudes below 150,000 ft)	Ft
	27-38	E12.5	HSCF -- Altitude at which shape change calculations terminate	Ft
*7	39-50	E12.5	HTJF -- Altitude at which trajectory calculations terminate	Ft
	3-14	E12.5	THT -- Initial longitude for trajectory calculation	Deg
	15-26	E12.5	PHGD -- Initial latitude for trajectory calculation	Deg
	27-38	E12.5	VELTJ -- Initial velocity for trajectory calculation	Ft/sec
	39-50	E12.5	GAMGD -- Initial flight path angle (should be negative value for reentry trajectory)	Deg
	51-62	E12.5	SIGGD -- Initial heading	Deg

INPUT TABLE 2. ENVIRONMENT TABLE

This table inputs environment conditions according to LG flag of Input Table 1. Maximum of 60 entries are allowed in this table.

1. Input for Flight Environment, LG = 1

Card No.	Columns	Format	Data	Units
1	1- 2	I2	Enter 02 (table number)	--
2	1- 2	I2	Nonzero entry for the last card in the table	--
	3-14	E12.5	Time	Sec
	15-26	E12.5	Altitude	Ft
	27-38	E12.5	Velocity	Ft/sec
3	Same as Card 2 for increasing time			
(etc.)				

2. Input for Wind Tunnel Environment, LG = 2

Card No.	Columns	Format	Data	Units
1	1- 2	I2	Enter 02 (table number)	--
2	1- 2	I2	Nonzero entry for the last card in the table	--
	3-14	E12.5	Time	Sec
	15-26	E12.5	Free stream total pressure	psia
	27-38	E12.5	Free stream total temperature	°F
	39-50	E12.5	Free stream Mach No. (a constant, entered on Card 2 only)	--
3	Same as Card 2 for increasing time			
(etc.)				

INPUT TABLE 2. Continued

3. Input for Ballistic Range Environment, LG = 3

	Card No.	Columns	Format	Data	Units
	1	1- 2	I2	Enter 02 (table number)	--
Projectile history	2	1- 2	I2	Nonzero entry for the last card in the table	--
		3-14	E12.5	Time	Sec
		15-26	E12.5	Projectile displacement down the range	Ft
		27-38	E12.5	Velocity	Ft/sec
	(3+n)	Same as Card 2 for increasing time			
Environment down the range	(n+1)	1- 2	I2	Nonzero entry for the last card in the table	--
		3-14	E12.5	Distance	Ft
		15-26	E12.5	Pressure	Atm
		27-38	E12.5	Temperature (Card (n+1) only)	°R
	(n+2)	Same as Card (n+1) with increasing distance			
	(etc.)				

4. Input for General Environment, LG = 4

Card No.	Columns	Format	Data	Units
1	1- 2	I2	Enter 02 (table number)	--
2	1- 2	I2	Nonzero entry for the last card in the table	--
	3-14	E12.5	Time	Sec
	15-26	E12.5	Free stream static pressure	Atm
	27-38	E12.5	Free stream static temperature	°R
	39-50	E12.5	Free stream velocity	Ft/sec
3	Same as Card 2 for increasing time			
(etc.)				

INPUT TABLE 2. Concluded

5. Input for Arc Heater Environment, LG = 5

	Card No.	Columns	Format	Data	Units
	1	1- 2	I2	Enter 02 (table number)	--
Model displacement history	2	1- 2	I2	Nonzero entry for the last card in the displacement history subset	--
		3-14	E12.5	Time	Sec
		15-26	E12.5	Displacement	Inch
	(3→n)	Same as Card 2 for increasing time			
Flow conditions	(n+1)	1- 2	I2	Nonzero entry for the last card in the flow conditions subset	--
		3-14	E12.5	Time	Sec
		15-26	E12.5	Free stream total pressure (p_{t_1})	Atm
		27-38	E12.5	Free stream total enthalpy (h_{t_1})	Btu/lbm
	(n+2→m)	Same as Card (n+1) with increasing time			
Pressure conditions	(m+1)	1- 2	I2	Nonzero entry for the last card in the table	--
		3-14	E12.5	Distance from nozzle exit	Inch
		15-26	E12.5	Normal shock total pressure ratio (p_{t_2}/p_{t_1})	--
	(m+2)	Same as Card m+1 with increasing distance			
	(etc.)				

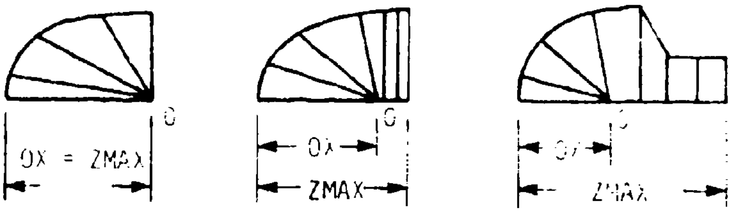
INPUT TABLE 3. INITIAL CONFIGURATION AND IN-DEPTH CONDUCTION GRID PARAMETERS

Card No.	Columns	Format	Data	Units
1	1- 2	I2	Enter 03 (table number)	--
2	1- 5	I5	NS -- Number of points on the heated surface of the body (maximum 50 points) >0 -- Sphere-core shape option (applicable only for single material bodies) <0 -- General shape option	--
	6-10	I5	NPN -- Number of points on the nose; applicable only to sphere-cone option (NS > 0)	--
	11-15	I5	MAT -- Material index for single material nosetip. If the nosetip is multimaterial (maximum of six in-depth materials, general shape option only) it may be entered as zero.	--
3	1- 2		Blank	
	3-14	E12.5	RNI -- Initial nose radius†	Inch
	15-26	E12.5	ZMAX -- Maximum axial length (required input for sphere-cone option only) ZMAX = Z-coordinate of the last point on the sphere-cone	Inch
	27-38	E12.5	THETA -- Initial cone half angle (required input for sphere-cone option only)	Deg
	39-50	E12.5	OX -- Axial position of the origin of the rays <0 -- Flat back option >0 -- Plug option	Inch

†Used to estimate transition altitude (or time), and for scaling of body input information

INPUT TABLE 3. Continued

Card No.	Columns	Format	Data	Units
3 (Continued)			The following sketches illustrate the nosetip configuration/location of the origin of the ray's combination which are referred to as flat back or plug configurations.	



a. Flat back (OX = ZMAX)   b. Plug (OX < ZMAX)

Card No.	Columns	Format	Data	Units
	51-62	E12.5	<u>TS</u> -- Initial body temperature. This input will be overridden if surface temperature distribution is input via Table 07.	°R
	63-74	E12.5	<u>STRD</u> -- (Transient option only, ISS = 0.) Maximum surface temperature rise desired between time steps. If it is less than 49°R or greater than 201°R, it is set to 75°R.	°R

- - - - - - - - - - - - - - - General Shape Option - - - - - - - - - - - - - - -

The generalized shape/interface option can be thought of as describing the boundary lines for each material in the vehicle. Each material interface should be described as a closed loop (i.e., one point should be specified twice). A simple sample will best illustrate the use of the new option. Consider a vehicle modeled by the following geometry:

INPUT TABLE 3. Continued

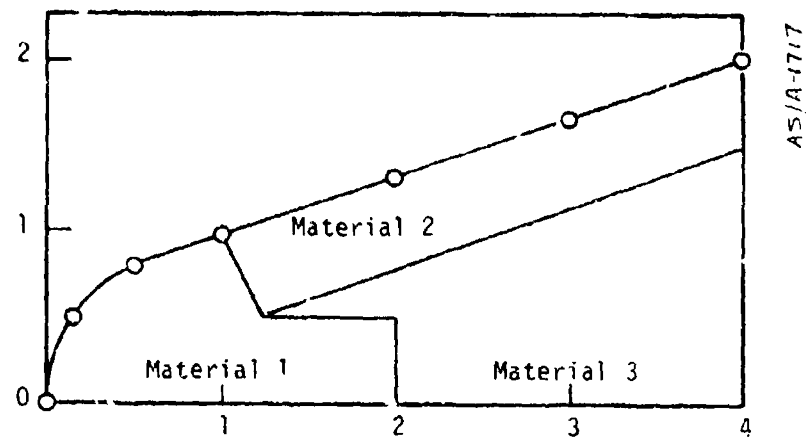
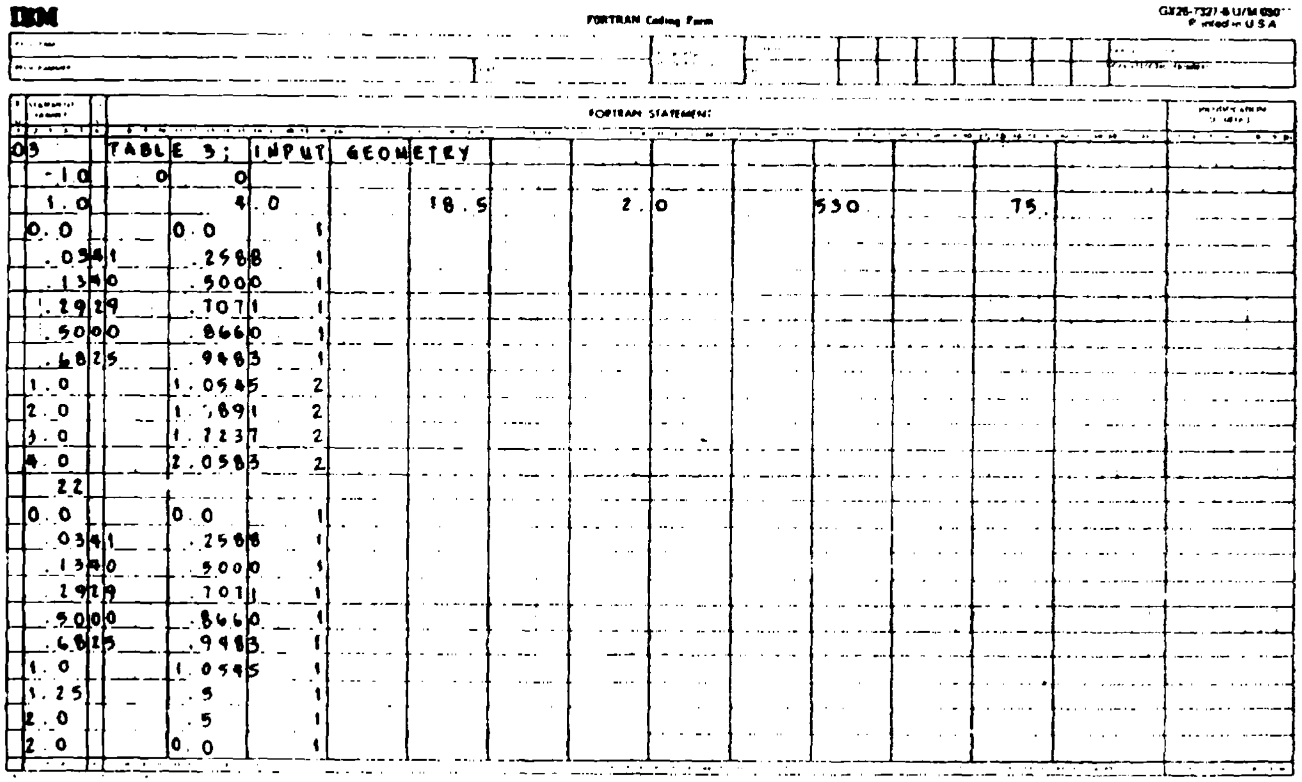


Table 3 input for this geometry is shown in Figure 3-1 with 10 surface points, models the interface with 22 input points, and has 1 plug point. Although the configuration appears as a flat back, the user has specified a plug option (Figure b, Page 3-14) so that the origin of rays may be placed closer to the nosetip for better implicit layer definition. As such, the user must specify the flat back face as an unheated surface. From this data, the code will calculate the coordinates and material flags of the interface intersections with ray within the implicit layer, and the material flag indices for the explicit grid, NMAT.

Card No.	Columns	Format	Data	Units
4	1-20	F10.3,F8.3,I2	ZSP(I), RSP(I), NB1(I) -- For I = 1, NS. Body point coordinates and material indices for the surface of the vehicle.	Inch
			Enter one surface point per card. Enter as many cards as there are surface points (NS).	
5	1- 5	I5	NIF -- Number of points used to describe the interfaces	--



```
03    TABLE 3; INPUT GEOMETRY
   -10         0         0
   1.0                 4.0           18.5           2.0          530.         75.
0.0                0.0         1
  .03411           .25888      1
  .13400           .50000      1
 1.29229           .70711      1
  .50000           .86600      1
  .68235           .94833      1
1.0               1.05455      2
2.0               1.1891       2
3.0               1.72337      2
4.0               2.05833      2
    22
0.0                0.0         1
  .03411           .25888      1
  .13400           .50000      1
  .19229           .70711      1
  .50000           .86600      1
  .68235           .94833      1
1.0               1.05455      1
1.25                .5         1
2.0                 .5         1
2.0                0.0         1
```

Figure 3-1. Sample Table 3 Input for General Shape/Interface Option

IBM

FORTRAN Coding Form

GX28-7327-6 U/M 050
Printed in U.S.A.

FORTRAN STATEMENT

```
 0.0          0.0           1
 1.0          1.0545        2
 4.0          2.0583        2
 4.0          1.5           2
 1.25         0.5           2
 1.0          1.0545        2
 1.25         0.5           3
 4.0          1.5           3
 4.0          0.0           3
 2.0          0.0           3
 2.0          0.5           3
 1.25         0.5           3
03    4.0             0.0
```

Figure 3-1. (Concluded)

INPUT TABLE 3. Continued

Card No.	Columns	Format	Data	Units
6	1-20	F10.3,F8.3,I2	ZIS(I), RIS(I), NBS(I) -- For I = 1, NIF. Coordinates and material indices for the interface locations. Enter one surface point per card. Enter as many cards as there are interface points (NIF).	Inch

If the geometry consists of only one material, the interface boundary is described first by tracing the surface body points then closing the loop.

- - - - - - - - - - - - - - - - Plug option only - - - - - - - - - - - - - - - -

(Read only if OX > 0)

Plug points identify the remaining surface points that are not on the heated surface. Note if a flat back configuration is specified as a plug (Figure b, page 3-14), that is OX > 0, then a single plug point is required, connecting the last surface point to the axis, which describes the unheated flat back face.

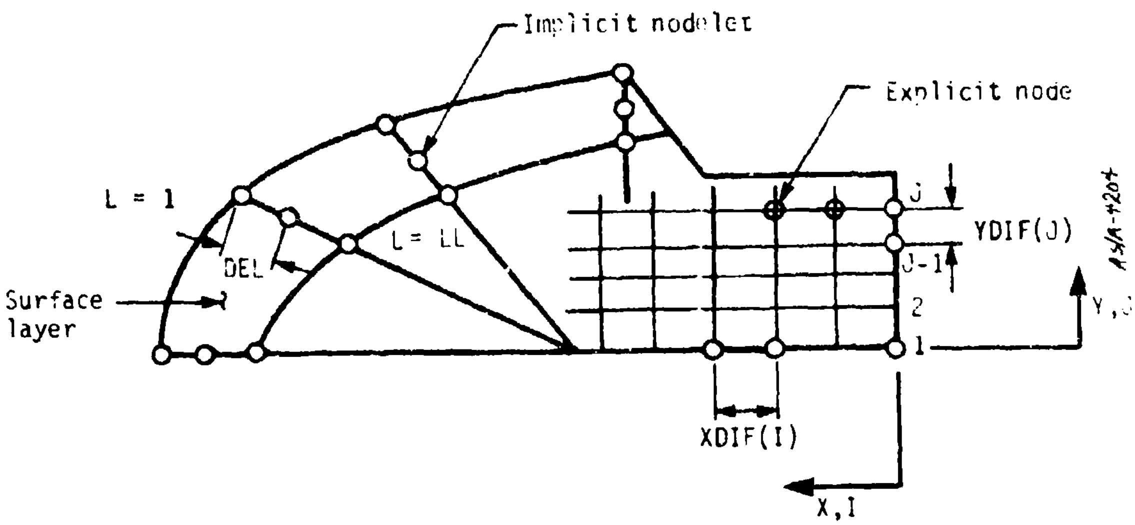
Card No.	Columns	Format	Data	Units
5	1- 2	I2	NC -- Flag to read the coordinates of the body points = 0 -- Keep reading ≠ 0 -- Stop reading. This indicates that the card is the last of its kind.	--
	3-14	E12.5	ZSP -- Body point axial length, (z)	Inch
	15-26	E12.5	RSP -- Body point radial length, (r)	Inch

INPUT TABLE 3. Continued

- - - - - - - - - - - - - - - In-depth grid setup - - - - - - - - - - - - - - -

(Transient option only: ISS = 0)

This in-depth grid definition and nomenclature are shown in the following sketch.



Comments on the Choice of the In-Depth Grid

The grid size and distribution are problem dependent. In general, there is no rule as to what the optimum value of the grid size is; and one has to perform some numerical experiments to arrive at the optimum value. The acceptable solution to the problem is the one which does not change when the grid size is further refined.

In order to obtain a rough estimate of the thickness of the surface layer, we use the results of steady-state analysis of a semi-infinite solid with constant surface temperature (or heat flux) and recession rate, $\dot{s}$. It can be shown that the thermal penetration depth in the solid is

$$D_p = \frac{2.3\alpha}{\dot{s}}$$

where α is the material thermal diffusivity and D_p is defined to be the distance from the receding surface to where the temperature drops to 10 percent of the surface temperature.

In the nosetip application, if we can estimate a characteristic recession rate, $\dot{s}$, we may state that the surface layer thickness should be greater than or at least equal to D_p obtained from the above formula.

For plug configuration the position of the origin of the rays on the axis of symmetry is input by the user. As a guide to determine the position of this origin, it should be noted that for accuracy of computations we desire the rays to be as close to the surface normals as possible. On the other hand, the distance OX should be large enough to allow the surface to recede without getting too close to the origin of the rays. The computations are set to stop if the distance from the back of the surface layer to the origin of the rays is anywhere smaller than DSMOVE unless the automatic shifting option is specified. In the former case, the computations can be continued by relocating the origin of the rays and using the code restart capability. The input format for the in-depth grid is as follows:

Implicit Grid

Card No.	Columns	Format	Data	Units
6	1- 5	I2	LL -- Total number of implicit nodes (nodlets) along each ray (maximum 15)	--
7	1- 2	I2	Blank	
	3-74	6E12.5	DELN(I) -- For I=2, LL; normalized nodlet spacing (normalized distance between nodlets, from surface inwards must sum to unity; maximum of 14). If uniform spacing is desired, enter only one spacing, DELN(2); i.e., 1/(LL-1) = uniform spacing.	--

INPUT TABLE 3. Concluded

Card No.	Columns	Format	Data	Units
8	1- 2	I2	Blank	
	3-74	6E12.5	DEL(I) -- For I=1, NS; surface layer thickness along each ray. If uniform thickness is desired, enter only one thickness, DEL(1)	Inch
9	1- 5	I5	IL -- Number of explicit nodes in the X-direction (maximum 60)	--
	6-10	I5	JL -- Number of explicit nodes in the Y-direction (maximum 25)	--
10	1- 2		Blank	
	3-74	6E12.5	XDIF(I) -- For I = 2, IL (six to a card), X-direction distance between grid nodes. For uniform grid spacing in both X and Y directions enter one value only, XDIF(2)	Inch
11	1- 2		Blank	
	3-74	6E12.5	YDIF(J) -- For J = 2, JL (six to a card), Y-direction distance between grid nodes	Inch

Not input for uniform grid spacing

- - - - - - - - - - - - Trajectory calculation option only - - - - - - - - - - - -

(Read only if LG = -1)

Card No.	Columns	Format	Data	Units
*12	3-14	E12.5	THETAC -- Frustum angle to be used in calculating the aft body drag	Deg
	15-26	E12.5	RBAS -- Vehicle base radius	Inch
	27-38	E12.5	VLN -- Vehicle axial length	Inch
	39-50	E12.5	XCG -- Vehicle center of gravity location from stagnation point	Inch
	51-62	E12.5	WT -- Vehicle weight	lbm

INPUT TABLE 4. TRANSITION TABLE

Enter this table only when NREYCR = 2, 3, or 4. Maximum of 30 entries are allowed in this table.

1. Input for Re_θ versus M_e, NREYCR = 2

Card No.	Columns	Format	Data	Units
1	1- 2	I2	Enter 04 (table number)	--
2	1- 2	I2	Nonzero entry for the last card in the table	--
	3-14	E12.5	AM -- Local edge Mach No. (M_e)	--
	15-26	E12.5	REM -- Critical momentum thickness Reynolds number (Re_θ)	--
3	Same as Card 2 for increasing M_e			
(etc.)				

2. Input for Re_s versus M_e, NREYCR = 3

Card No.	Columns	Format	Data	Units
1	1- 2	I2	Enter 04 (table number)	--
2	1- 2	I2	Nonzero entry for the last card in the table	--
	3-14	E12.5	AM -- Local edge Mach No. (M_e)	--
	15-26	E12.5	REM -- Critical steam-length Reynolds number (Re_s)	--
3	Same as Card 2 for increasing M_e			
(etc.)				

INPUT TABLE 4. Concluded

Card No.	Columns	Format	Data	Units
			3. Input for axial transition location versus altitude (time), IIREYCR = 4	
1	1- 2	I2	Enter 04 (table number)	--
2	1- 2	I2	Nonzero entry for the last card in the table	--
	3-14	E12.5	AM -- Altitude (LG = 1 or 3) or time (LG = 2, 4, or 5)	Ft or sec
	15-26	E12.5	REM -- Axial transition location from current stagnation point	Inch
3	Same as Card 2 for increasing altitude (time)			

INPUT TABLE 5. PARTICLE ENVIRONMENT

This table is not required for clear air calculations. Three options are allowed for cloud characterization with a maximum of 50 entries in each.

Card No.	Columns	Format	Data	Units
1	1- 2	I2	Enter 05 (table number)	--
*2	1- 5	I5	NOSLO -- Shock layer particle interaction flag	--
			≤ 0 -- Interaction model is a function of the altitude and is input in the following tables	
			1 -- No interaction	
			2 -- Jaffe model	
			3 -- Reinecke and Waldman model	
			4 -- Ranger and Nicholls model	
	6-10	I5	NOHEAL -- Ablation healing flag	--
			0 -- No crater healing	
			1 -- Crater healing	
	11-15	I5	METER -- Input units flag	--
			0 -- Altitudes in feet	
			1 -- Altitudes in meters	
*	16-20	I5	INPUT -- Distribution flag	--
			0 -- Constant particle size	
			1 -- Built-in distributions	
			2 -- Input distributions	
			Option 2 (INPUT = 0)	
3	1- 2	I2	NC -- Nonzero entry for last card	--
	3-10	F8.1	ALCL -- Altitude (LG = 1) or distance along range (LG = 3)	Ft or meter

INPUT TABLE 5. Continued

Card No.	Columns	Format	Data	Units
	11-20	F10.2	CZI -- Liquid water content	gm/m^3
	21-30	F10.2	DPI -- Particle diameter	Microns
	31-40	F10.2	SGI -- Particle specific gravity	--
*	41-50	F10.2	TYP -- Particle type	--
			1.0 -- Ice	
			2.0 -- Small snow	
			3.0 -- Large snow	
			4.0 -- Rain	
*	60	I1	NDEM -- Particle/shock-layer interaction model. Not used if NOSLO > 0.	--
			1 -- No interaction	
			2 -- Jaffe model	
			3 -- Reinecke and Waldman model	
			4 -- Ranger and Nicholls model	
4	Same as Card 3 for increasing or decreasing altitude			
(etc.)				

Option 2 (INPUT = 1)

Card No.	Columns	Format	Data		Units
*3	1- 2	I2	NC	Same as Option 1	-
	3-10	F8.1	ALCL		-
	11-20	F10.2	CZI		-
	21-30	F10.2	TYP		-
	31-40	F10.2	SGI		-
	50	I1	NDEM		-

INPUT TABLE 5. Concluded

Card No.	Columns	Format	Data	Units
			Option 3 (INPUT = 2)	
*3	1- 2	I2	NC — Same as Option 1	-
	3-10	F8.1	ALCL — Same as Option 1	-
	11-20	F10.2	CZI — Same as Option 1	-
	21-30	F10.2	TYP — Same as Option 1	-
	31-40	F10.2	DMAX -- Maximum particular diameter	Microns
	41-50	F10.2	ANO -- N_0 — Parameters used to describe distribution function $N(D) = N_0 \cdot e^{-\lambda dp}$	#/m^3-mm†
	51-60	F10.2	ALAM -- λ — Parameters used to describe distribution function $N(D) = N_0 \cdot e^{-\lambda dp}$	-
	61-70	F10.2	SGI — Same as Option 1	-
	80	I2	NDEM — Same as Option 1	-

INPUT TABLE 6. MATERIAL PROPERTIES

Maximum of three material inputs are allowed in this table. Each material input is treated according to the following format.

Card No.	Columns	Format	Data	Units
1	1- 2	I2	Enter 06 (table number)	-
2	1- 5	I5	MAT -- Material index for following table	-
	6-10	I5	NERODE -- Erosion law material flag 0 -- No erosion 1 -- Generalized G-law erosion 2 -- Carbon-phenolic law 3 -- Tungsten law	-
	11-15	I5	JROUGH -- Laminar heating augmentation flag 0 -- No augmentation 1 -- Transition proximity augmentation 2 -- Transition proximity and particle stirring augmentation with correlation of metallic data $H = 0.1193\,\rho_\infty u_\infty \left(\frac{w_{x,impact} u_p}{\rho_\infty u_\infty}\right)^{0.382}$ 3 -- Particle stirring augmentation with correlation for graphite data $H = 0.098 \left[\frac{w_{x,impact} u_p}{\rho_\infty u_\infty}(1 + G)\right]^{0.317}$	-
3	1- 2		Blank	
	3-14	E12.5	RUFL -- Intrinsic roughness height	Mil
	15-26	E12.5	RUFMAX -- Maximum turbulent roughness height ($k_{t_{max}}$)	Mil
	27-38	E12.5	RUF1 -- Constant k_1 >0 -- White-Grabow scallop law is used: $k_t = k_1 P_e^{-0.77}$ with $k_{t_{max}}$ = RUFMAX	MIL-psi^0

INPUT TABLE 6. Continued

Card No.	Columns	Format	Data		Units
			=0 -- Constant turbulent roughness of RUFMAX is used		
4	1- 2		Blank. If NERODE = 0, this card is not required.		
	3-14	E12.5	A	Constants for generalized G-law erosion (this card required only	
	15-26	E12.5	B	if NERODE = 1) where:	--
	27-38	E12.5	C	$G = A(u_p)^B (d_p)^C (m_p)^D (\sin\theta)^E (T_w)^F$	--
				u_p = Impact velocity in ft/sec	--
	39-50	E12.5	D	d_p = Particle diameter in micron	--
	51-62	E12.5	E	m_p = Mass of the particle in lbm	--
	63-74	E12.5	F	T_w = Surface temperature in °R	--
	75-80	E6.0	DPARTM		
			>0 -- Minimum-particle diameter used in carbon-carbon G-law		Microns
			<0 -- Use graphite G-law		

Parameters in Blowing Correction to Transfer Coefficients

Card No.	Columns	Format	Data	Default Values	Units
5	1- 2	I2	NC -- Flag, zero for ISS = 0 or 1. For ISS = 2, use -1 for terminal card of an intermediate material table and +1 for last material table. The input of the rest of Input Table 6, except card 9 is not required if ISS = 2.		--
	3-14	E12.5	BLS -- Laminar shear parameter	0.5	--
	15-26	E12.5	BLH -- Laminar heating parameter	0.5	
	27-38	E12.5	BTS -- Turbulent shear parameter	0.35	--
	39-50	E12.5	BTH -- Turbulent heating parameter	0.35	--

If zero is entered, default values are used.

INPUT TABLE 6. Continued

Card No.	Columns	Format	Data	Units
6	1- 2		Blank	--
	3-14	E12.5	RHO -- Material density	lbm/ft^3
	15-26	E12.5	TFO -- Datum temperature for heat of formation. For JANAF data TFO = 36°R.	°R
	27-38	E12.5	HFO -- Heat of formation	Btu/lbm
7	1- 2		Blank; if non-melting material, enter a blank card	
	3-14	E12.5	XLATHT -- Latent heat of fusion for melting material	Btu/lbm
	15-26	E12.5	TMELT -- Melt temperature	°R
	27-38	E12.5	DTMELT -- Temperature difference over which melt is to occur	°R
	39-50	E12.5	CPSOLD -- Specific heat of so[illegible]	Btu/lbm-°R
	51-62	E12.5	CPLIQD -- Specific heat of [illegible] a[illegible] TMELT	Btu/lbm-°R
8	1- 2	I2	NC -- Flag, nominally zero, +1 [illegible] terminal card of last material pr[illegible]ty table, -1 marks terminal card of intermediate material property tables	--
	3-14	E12.5	Temperature (independent variable)	°R
	15-26	E12.5	Specific heat	Btu/lbm-°R
	27-38	E12.5	Thermal conductivity (not required for the steady-state option)	Btu/ft-sec-°R
	39-50	E12.5	Emissivity	--

Additional materials (if any) follow in a similar manner, starting with Card 2.

INPUT TABLE 6. Concluded

Card No.	Columns	Format	Data	Units
			Contact Resistance	
9	1- 5	I5	MAT1 -- Material number	--
	6-10	I5	MAT2 -- Material number	--
	11-22	E12.5	VALUE -- Contact resistance between MAT1 and MAT2	Ft^2-S-°R/Btu

Enter contact resistance between each pair of materials only once, i.e., if MAT1 = 2 and MAT2 = 5 it is not necessary to enter a contact resistance for the pair MAT1 = 5 and MAT2 = 2. Terminate entries with a blank card; if there are no contact resistances, the blank card is still required.

INPUT TABLE 7. SURFACE DATA

The BRLASCC code includes sophisticated techniques to predict surface pressure, temperature, and blowing rate distributions of ablating surfaces. The user, however, may bypass these computations and enter the desired surface pressure, temperature, or blowing rate distributions via this table. Entries for each variable are described in the following subsections. Any combination of one or three subsections can be input. Maximum of 60 entries are allowed in each subtable.

Card No.	Columns	Format	Data	Units
			Pressure	
1	1- 2	I2	Enter 07 (table number)	--
2	1- 5	I5	ITABL -- Enter 1 (pressure table)	--
	6-10	I5	IPRFLG	--
			1 -- Surface pressure ratio given as function of axial distance	
			2 -- Surface pressure ratio given as function of dimensionless stream length (S/R_N) where R_N is the nose radius	
3	1- 2	I2	Nonzero entry for the last card in the table (-1, if other surface tables follow, +1 for last surface table)	--
	3-14	E12.5	Axial distance from stagnation point (IPRFLG = 1)	Inch
			or, dimensionless stream length (S/R_N) (IPRFLG = 2)	--
	15-26	E12.5	Pressure ratio (p/p_{t_2})	--
4	Same as Card 3 for increasing distance or S/R_N			

INPUT TABLE 7. Concluded

Card No.	Columns	Format	Data	Units
			Temperature	
m	1- 5	I5	ITABL -- Enter 2 (temperature table)	--
	6-10	I5	ITMFLG	--
			1 -- Surface temperature as a function of axial distance	
			2 -- Surface temperature as a function of dimensionless stream length (S/R_N)	
m+1	1- 2	I2	Nonzero entry for last card in table (-1, if other surface tables follow, +1 for last surface table)	--
	3-14	E12.5	Axial distance from stagnation point (ITMFLG = 1)	Inch
			or dimensionless stream length (S/R_N) (ITMFLG = 2)	--
	15-26	E12.5	Temperature	°R
(m+2) (etc.)	Same as Card m+1 for increasing distance			
			Blowing Rate	
n	1- 5	I5	ITABL -- Enter 3 (blowing rate table)	--
	6-10	I5	IBRFLG	--
			1 -- Blowing rate (B') as a function of axial distance	
			2 -- Blowing rate (B') as a function of dimensionless stream length (S/R_N)	
n+1	1- 2	I2	Nonzero entry for last card in table (-1, if other surface tables follow, +1 for last surface table)	--
	3-14	E12.5	Axial distance from stagnation point (IBRFLG = 1)	Inch
			or dimensionless stream length (S/R_N), (IBRFLG = 2)	--
	15-26	E12.5	Blowing parameter $B' \equiv \rho_w v_w / \rho_e u_e C_M$	--
(n+2) (etc.)	Same as Card n+1 for increasing distance			

INPUT TABLE 8. SHOCK SHAPE DATA

The ASC code includes state-of-the-art shock shape prediction capability. The user may, however, bypass the code shock shape calculations and input the shock coordinates and shock angle as a function of shock radial coordinate via this table. Maximum of 150 entries are allowed in this table.

Card No.	Columns	Format	Data	Units
1	1- 2	I2	Enter 08 (table number)	--
2	1- 5	I5	ISHFLG -- Shock shape flag 1 -- Shock angle given as function of y-coordinate 2 -- Shock angle given as function of dimensionless y-coordinate (y/R_N), where R_N is the nose radius	--
3	1- 2	I2	Nonzero entry for the last card in the table	--
	3-14	E12.5	y-coordinate (for ISHFLG = 1) or dimensionless y-coordinate (y/R_N), (ISHFLG = 2)	Inch
	15-26	E12.5	Shock angle	Degrees
	If Table 5 is entered with the parameter NOSLO = 2, 3, or 4, the x-coordinate† of the shock must also be entered according to the following format:			
	27-38	E12.5	x-coordinate (for ISHFLG = 1) or dimensionless x-coordinate (x/R_N) (ISHFLG = 2)	Inch
4	Same as Card 2 for increasing y or y/R_N			
	For normal shock calculation, make a table having one entry with shock angle of 90°.			

†This input is required for weather calculations with demise.

INPUT TABLE 9. SURFACE THERMOCHEMISTRY

Table 9 consists of the parameters necessary for the surface energy balance formulation. For multimaterial nosetips, the same format is repeated for each material. Different material thermochemistry tables must be separated by a blank card, and the final table is terminated by two blank cards.

Card No.	Columns	Format	Data	Units
1	1- 2	I2	Enter 09 (table number)	--
2	1- 5	I5	MAT -- Material index number	--
3	1- 2		Blank	--
	3-14	E12.5	CMH -- Ratio of mass to heat transfer coefficients (typically 1.0)	--

Edge Tables

If diffusion coefficients are not equal or if the ratio C_M/C_H is not unity, then the surface energy balance requires data about the edge gases of the boundary layer. These data are provided in special "edge tables" which precede each pressure section of the surface tables (the various sections of the surface tables are described below). The independent variables for an edge table are pressure and temperature. Dependent variables are $h_e^{T_w}$ and the sum $\Sigma z_{i_e}^{*} h_i^{T_w}$.

Card No.	Columns	Format	Data	Units
4	1- 8	F8.5	Pressure	Atm
	9-24		Blank	--
	25-33	F9.4	Temperature	(°R if negative in which case enthalpies below are Btu/lbm)

INPUT TABLE 9. Continued

Card No.	Columns	Format	Data	Units
4 (Continued)	34-38	F5.3	Unequal diffusion exponent γ	--
	39-47	F9.3	Summation $\Sigma z_{i_e}^{*} h_i^{T_w}$	cal/gr (Btu/lbm if temperature is entered with minus sign)
	48-56	F9.3	Enthalpy of edge gases $h_e^{T_w}$ evaluated at T_w	cal/gr (Btu/lbm if temperature is entered with minus sign)
	57-58	I2	-1 (flag signifying that this card is part of the edge gas table)	--
5 (etc.)	Same as Card 4 for remaining entries in "edge table" for this pressure, maximum of 12 temperatures for each pressure.			

The table length is limited to 5 pressure sets (it may have only 1 pressure set) with not more than 12 nor less than 3 temperature entries in each set. The series of temperature values may be different for the edge table at each pressure set. The table is organized as a series of sections, each representing one pressure and each preceding the corresponding pressure group of the surface thermochemistry deck as described below. The temperature entries within each section must be ordered, either ascending or descending. Similarly, the pressures must be ordered either ascending or descending. Decks generated by Aerotherm thermochemistry programs will have been automatically ordered properly.

INPUT TABLE 9. Continued

Surface Thermochemistry Tables

Description of Surface Thermochemical Tables

This table comprises a series of sections. Each section represents one pressure and one transfer coefficient value. More than one transfer coefficient may be necessary if the effects of kinetics on the surface response are considered. Nondimensional ablation rate, B'_{tc}, forms the third independent variable within a given section. The table has three dependent variables: $\Sigma z^*_{iw} h_i^{T_w}$, $h_w^{T_w}$, and T_w.

The Aerotherm thermochemistry codes generate separate groups for each pressure, one at a time. All these groups together make up the surface thermochemistry deck. Within each pressure group the transfer coefficient values will be ordered. Within each transfer coefficient section, ablation rate entries need not be ordered in any particular way on the ablation rates; any necessary ordering is made automatically by the code as it reads in the data.

Users providing their own thermochemistry decks must ensure that the transfer coefficients are ordered, but the ordering may be either ascending or descending in each case. The surface thermochemistry cards are identified by a unity flat in Column 58, as described in the format specification below.

The number of pressure groups may not exceed 5 (and may be only 1); the number of transfer coefficient values in each pressure group may not exceed 5 but may be only 1. If no kinetics effects are to be considered, a transfer coefficient of zero is acceptable. The sequence of transfer coefficient values need not be the same in the different pressure sections. Within each transfer coefficient section the number of ablation rate entries may not

INPUT TABLE 9. Continued

exceed 25 and may not be less than 2. The series of ablation values, B'_{tc}, may be unique for each section.

The °R-Btu/lb option described for the edge tables may be used for these tables also.

Card Formats

Card No.	Columns	Format	Data	Units
n	1- 8	F8.5	Pressure	Atm
	9-16	F8.5	Transfer coefficient†	lb/ft^2-sec
	17-24	F8.5	Nondimensional ablation rate $\dot{m}/\rho_e u_e C_M = B'$	--
	25-33	F9.4	Surface temperature	°K (°R is negative in which case enthalpies below are Btu/lbm.)
	34-38	F5.3	Unequal diffusion exponent γ	--
	39-47	F9.3	Summation $\Sigma z^*_{iw} h_i^{T_w}$	cal/gr (Btu/lbm if temperature is entered with minus sign)
	48-56	F9.3	Enthalpy of wall gases $h_w^{T_w}$	cal/gr (Btu/lbm if temperature is entered with minus sign)
	57-58	I2	Flag indicating surface thermochemistry table entry	--
	59-60		Blank	--

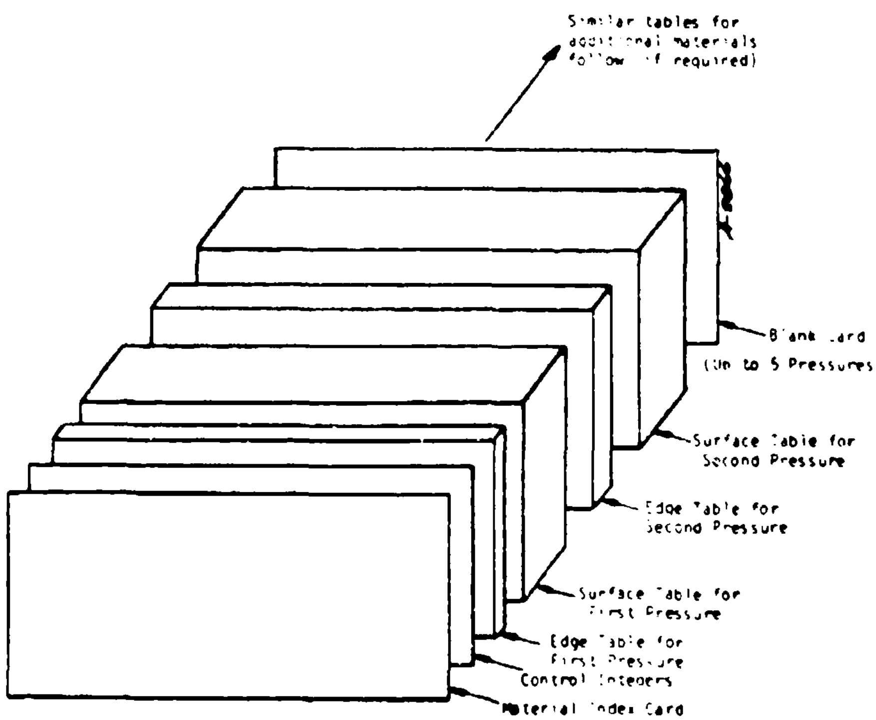
†Must be provided by the user.

INPUT TABLE 9. Continued

Card No.	Columns	Format	Data	Units
n (Continued)	61-66	A6	Chemical symbol of surface species. (Aerotherm ACE and GASKET programs print such symbols arranged alphabetically and truncated from right end if necessary)	--
	67-78	E12.3	Nondimensional mechanical fail rate = $\dot{m}^{*}/\rho_e u_e C_M = B'_{fail}$ (TBFP)	--
n+1	Same as Card n for remaining entries in this section; maximum of 25 entries in each section.			

<u>Assembled Thermochemical Deck</u>

The following sketch shows a picture of an assembled thermochemical data deck for a given material and several pressures. The deck corresponds to repeating the input described previously for each pressure.



Sketch of surface thermochemistry table makeup for a given material including leading constant cards.

INPUT TABLE 9. Concluded

The surface equilibrium data deck for each material must be terminated by a single blank card. Output decks of Aerotherm thermochemistry programs do not have such a card, and the user must supply it. Thermochemical data decks for additional materials (if required) follow in a similar manner. The last material thermochemistry table is terminated by two blank cards.

End of Input

The end of the input data deck for each case is signaled by a single card with a -1 punched in Columns 1 and 2. The end of the overall input data deck is signaled by a -1 punched in Columns 4 and 5.

3.2 SAMPLE PROBLEM

This subsection presents a sample problem that demonstrates the capability of the improved ASC code, BRLASCC. The problem consists of a long slender multimaterial configuration with an in-depth melting material. The objective of the analysis is to determine if the outer material "burns through" to the inner materials. Sample JCL for file assignments on VAX/VMS systems and a complete listing of the input data is presented, while only a selected listing of the output (which is voluminous) is presented.

The vehicle is a slightly modified Army projectile. The nose, originally sharp, has been given a small radius to facilitate gridding in the nose region. The vehicle is biconic, 12.5° on the nose with an 8° afterbody.

The BRLASCC solution failed to converge to a proper surface energy balance during Environment 8. A restart was undertaken from Environment 7 and is shown as part of the sample output. Asterisks next to the total recession rate and B' thermochemical printout at Surface Point 1 on the "Body Point Location and Surface Energy Balance Results" summary page indicate that nose modeling logic which prevents indented shapes from occurring is being used.

BRLASCC indicates that burnthrough does indeed occur at sometime near 0.59 s.

The sample VAX/VMS DCL command procedure to assign files for I/O and run BRLASCC is shown below.

```
$!---------------------------------------------------------------------!
$!                                                                     !
$!                          RUNBRL.COM                                 !
$!                                                                     !
$!             COMMAND PROCEDURE TO RUN BRLASCC                        !
$!                                                                     !
$!---------------------------------------------------------------------!
$!
$    SET NOVERIFY
$    SET DEFAULT [directory name]
$!
$    ASSIGN RUN.LOG SYS$PRINT
$    ASSIGN RUN.LOG SYS$OUTPUT
$!
$    ASSIGN    input data filename    FOR005
$    ASSIGN    output data filename   FOR006
$!
$    ASSIGN    ENVIRON.OUT            FOR001
$    ASSIGN    RESTART.F14            FOR014
$    ASSIGN    TRAJECT.DAT            FOR020
$!
$    RUN [executable image directory name]BRLASCC.EXE
$!
$    ERASE:
$         RUN__LOG = F$SEARCH("RUN.LOG")
$         IF RUN__LOG .EQS. "" THEN GOTO NO__LOG
$         DELETE RUN.LOG;*
$!
$    NO__LOG:
$         TRAJ = F$SEARCH("TRAJECT.DAT")
$         IF TRAJ .EQS. "" THEN $EXIT
$         DELETE TRAJECT.DAT;*
$!
$    EXIT
```

```
   0    0    0    0
         BRL FLIGHT CASE (YUMA  TC=125 DEG-F, T0=60 DEG-F)
         SAMPLE TRANSIENT CONDUCTION SOLUTION -- BPLASCC
          12 5 DEG NOSE, 7 INCH BODY  -- 1 SEPTEMBER 1983       SAMPLE
01     Program Constants and Time Information
   0 0         2 00
   4    0    1    5    0    1              0
   0 01        0 01
   0 25        0 25
01 0 25        2 00
02     Environment Table
   0 0         1 0         520         5259
   0 2         1 0         520         5184
   0 4         1 0         520         5082
   0 6         1 0         520         4941
   0 8         1 0         520         4793
   1 0         1 0         520         4636
   1 2         1 0         520         4446
   1 4         1 0         520         4249
   1 6         1 0         520         4035
   1 8         1 0         520         3839
02 2 0         1 0         520         3629
03     Surface Geometry and Grid Size
  -13
   0 2                                 1 5        585        75
   0 4507  0 0      1
   0 4627  0 0684   1
   0 4975  0 1286   1
   0 6074  0 1953   1
   0 8       2380   1
   1 0       2823   1
   1 249     3375   1
   1 55      3798   1
   1 9       429    2
   3 0       5836   2
   4 0       7241   2
   5 5     0 9349   2
   7 0     1 1458   2
   34
   0 4507  0 0      1
   0 4627  0 0684   1
   0 4975  0 1286   1
   0 6074  0 1953   1
   0 8       2380   1
   1 0       2823   1
   1 249     3375   1
   1 55      3798   1
   1 875     425    1
   1 94      32     1
   1 76      291    1
   1 76      226    1
   1 268     1571   1
   1 268     0775   1
   0 80      0775   1
   0 80    0 0      1
   0 4507  0 0      1
   0 80    0 0      2
   0 80      0775   2
   1 76      0775   2
   1 76      291    2
```

```
   1 94      32    2
   1 875     425   2
  2 0        4431  2
  4 0        7241  2
  6 0      1 2052  2
  7 0      1 1458  2
   7 0     0 0     2
   0 60    0 9     2
   1 268     0775  3
   1 268     1571  3
   1 76      2260  3
   1         0775  3
   1 208     0775  3
03  7 0            0 0
  11
    1
   .12
  60   22
 0 1186       0 1186    0 1186     0 1186     0 1186     0 1186
 0 1186       0 1186    0 1186     0 1186     0 1186     0 1186
 0 1186       0 1186    0 1186     0 1186     0 1186     0 1186
 0 1186       0 1186    0 1186     0 1186     0 1186     0 1186
 0 1186       0 1186    0 1186     0 1186     0 1186     0 1186
 0 1186       0 1186    0 1186     0 1186     0 1186     0 1186
 0 1186       0 1186    0 1186     0 1186     0 1186     0 1186
 0 1186       0 1186    0 1186     0 1186     0 1186     0 1186
 0 1186       0 1186    0 1186     0 1186     0 1186     0 1186
 0 1186       0 1186    0 1186     0 1186     0 1186
 0 055        0 055       0 055      0 055      0 055      0 055
 0 055        0 055       0 055      0 055      0 055      0 055
 0 055        0 055       0 055      0 055      0 055      0 055
 0 055        0 055       0 055      0 055      0 055      0 055
06   Material Pr  erties Table
   1    0
  10 0        0 0

  418 08      536 0        0 0

   400          083        1 794E-02       15
   500          088        1 805E-02       15
   600          093        1 790E-02       15
   700          098        1 758E-02       15
   800          103        1 718E-02       15
   900          108        1 670E-02       15
  1000          112        1 618E-02       15
  1100          117        1 563E-02       15
-1 1200         122        1 506E-02       15
   2    0    1
  10 0          0 0

  490          536 0        0 0

   492          11         7 360E-03       60
   672          11         7 220E-02       60
  1032          11         6 940E-02       60
-1 1392         11         6 110E-03       60
   3    0    1
  0 0           0 0

  488 8        536
```

```
  117 0        3310        50          128        1932
   540          128        7 56E-03          5
  3250          128        7 56E-03          5
  3320         1932        2 10E-03          5
+1 9000        1932        2 10E-03          5
   1     2  1 0E-05
   1     3  1 0E-04
   2     3  1 0E-06

09      Surface Chemistry Tables
   1
   1 0
 1 00      00    99 00   662 210   00   99 556   58 744   1  AC41A*       990+02
 1 00      00    10 00   659 444   00   89 850   58 408   1  AC41A*       100+02
 1 00      00     1 00   656 666   00   89 128   58 087   1  AC41A*       100+01
 1 00      00     01     653 888   00   88 405   57 765   1  AC41A*       100-01
 1 00      00     001    600 000   00   74 555   74 555   1  AIR
 1 00      00     0001   298 000   00   0        0        1  AIR
 1 00      00     00001  200 000   00  -42 130  -42 130   1  AIR

   2
   1 0
 1 00      00     01     2500 00   00  525 096  525 096   1  AIR
 1 00      00     001    600 000   00   74 555   74 555   1  AIR
 1 00      00     0001   298 000   00   0        0        1  AIR
 1 00      00     00001  200 000   00  -42 130  -42 130   1  AIR

   3
   1 0
 1 00      00     01     2500 00   00  525 096  525 096   1  AIR
 1 00      00     001    600 000   00   74 555   74 555   1  AIR
 1 00      00     0001   298 000   00   0        0        1  AIR
 1 00      00     00001  200 000   00  -42 130  -42 130   1  AIR

-1
  -1
```

```
BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)                                SAMPLE
                                                                              PAGE    1

                             *************
*********************************** I N P U T ***********************************
                             *************

          BRL FLIGHT CASE (YUMA  TS=125 DEG-F, T0=60 DEG-F)
          SAMPLE TRANSIENT CONDUCTION SOLUTION -- BRLASCC
          12.5 DEG NOSE, 7 INCH BODY  -- 1 SEPTEMBER 1983     SAMPLE

                    --- GENERAL PROGRAM FLAGS ---

             (ENVIRONMENT FLAG)                        LG =  4
             (SHAPE CHANGE FLAG)                      ISS =  0
             (OUTPUT PRINT FLAG)                    IPRNT =  1
             (TRANSITION CRITERIA FLAG)            NREYCR =  5
             (BODY ANGLE DEFN. FLAG)                 IRON =  0
             (CARBON TRANS. CRIT. FLAG)             ICARB =  1
             (NOSE SHAPE MODIFICATION FLAG)          IMOD =  0

                  --- TIME INCREMENT INFORMATION ---

INITIAL TIME (SEC)    0.0000          FINAL TIME (SEC)    2.0000

OUTPUT INTERVAL =  0.0100 SEC FROM  INITIAL TIME UNTIL    0.0100 SEC
OUTPUT INTERVAL =  0.2500 SEC FROM    0.0100 SEC UNTIL    0.2500 SEC
OUTPUT INTERVAL =  0.2500 SEC FROM    0.2500 SEC UNTIL FINAL TIME

                 ***************************************
                 TIME STEP STABILITY CRITERIA IN EFFECT
                 ***************************************

                 MINIMUM TIME STEP = 1.000E-06 SECONDS
```

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

--- GENERAL ENVIRONMENT ---

TIME (SEC)	PRESSURE (ATM)	TEMPERATURE (DEG R)	VELOCITY (FPS)
0.000	1.000	520.00	5259.00
0.200	1.000	520.00	5184.00
0.400	1.000	520.00	5082.00
0.600	1.000	520.00	4941.00
0.800	1.000	520.00	4793.00
1.000	1.000	520.00	4636.00
1.200	1.000	520.00	4446.00
1.400	1.000	520.00	4249.00
1.600	1.000	520.00	4035.00
1.800	1.000	520.00	3839.00
2.000	1.000	520.00	3629.00

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

--- INITIAL GEOMETRY ---

GENERAL SHAPE

INITIAL NOSE RADIUS = 0.2000 INCHES

GENERAL INTERFACE OPTION

PLUG OPTION

MAXIMUM •Z• = 7.0000 INCHES
ORIGIN OF RAYS (Z) = 1.5000 INCHES
ORIGIN OF RAYS (R) = 0.0000 INCHES

BODY POINT INDEX	SURFACE COORDINATES Z (INCH)	R (INCH)	THETA (DEG)	MATERIAL INDEX	OUTER INTERFACE COORDINATES Z (INCH)	R (INCH)	MATERIAL INDEX	INNER INTERFACE COORDINATES Z (INCH)	R (INCH)	MATERIAL INDEX
1	0.4507	0.0000	90.00	1	0.8000	0.0000	2	0.8000	0.0000	2
2	0.4627	0.0684	70.02	1	0.8000	0.0462	2	0.8000	0.0462	2
3	0.4975	0.1286	49.97	1	0.8959	0.0775	2	0.8959	0.0775	2
4	0.6074	0.1953	23.87	1	1.1458	0.0775	2	1.1458	0.0775	2
5	0.8000	0.2380	12.49	1	1.2680	0.0789	3	1.2721	0.0775	2
6	1.0000	0.2823	12.50	1	1.2680	0.1310	3	1.3627	0.0775	2
7	1.2490	0.3375	10.45	1	1.3723	0.1717	3	1.4424	0.0775	2
8	1.5500	0.3798	8.00	1	1.5500	0.1966	3	1.5500	0.0775	2
9	1.9000	0.4290	8.00	2	1.9000	0.3846	1	1.9000	0.3156	2
10	3.0000	0.5836	8.00	2	3.0000	0.5836	2	3.0000	0.5836	2
11	4.0000	0.7241	8.00	2	4.0000	0.7241	2	4.0000	0.7241	2
12	5.5000	0.9349	8.00	2	5.5000	0.9349	2	5.5000	0.9349	2
13	7.0000	1.1458	8.00	2	7.0000	1.1458	2	7.0000	1.1458	2

THE FOLLOWING POINTS ARE ON THE PLUG

14	7.0000	1.1458
15	7.0000	0.0000

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

SAMPLE
PAGE 4

*** INITIAL SHAPE OF NOSETIP ***

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

SAMPLE
PAGE 5

---IMPLICIT NODE SPACING---
NODE THICKNESS IN INCHES

NODE NO / BODY PT NO	1	2	3	4	5	6	7	8	9	10	11
1	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	
2	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	
3	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	
4	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	
5	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	
6	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	
7	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	
8	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	
9	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	
10	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	
11	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	
12	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	
13	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	

```
BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)                                    SAMPLE
                                                                                  PAGE   6

      --- EXPLICIT GRID GEOMETRY ---

        NUMBER OF COLUMNS   =    60
        NUMBER OF ROWS      =    22

        VARIABLE GRID SPACING WITH
        X GRID SPACING =
0.11860     0.11860     0.11860     0.11860     0.11860
0.11860     0.11860     0.11860     0.11860     0.11860
0.11860     0.11860     0.11860     0.11860     0.11860
0.11860     0.11860     0.11860     0.11860     0.11860
0.11860     0.11860     0.11860     0.11860     0.11860
0.11860     0.11860     0.11860     0.11860     0.11860

0.11860     0.11860     0.11860     0.11860     0.11860
0.11860     0.11860     0.11860     0.11860     0.11860
0.11860     0.11860     0.11860     0.11860     0.11860
0.11860     0.11860     0.11860     0.11860     0.11860
0.11860     0.11860     0.11860     0.11860     0.11860
0.11860     0.11860     0.11860     0.11860
        Y GRID SPACING =
0.05500     0.05500     0.05500     0.05500     0.05500
0.05500     0.05500     0.05500     0.05500     0.05500
0.05500     0.05500     0.05500     0.05500     0.05500
0.05500     0.05500     0.05500     0.05500     0.05500
0.05500

     INITIAL TEMPERATURE OF MODEL =  585.0 DEG R

MAXIMUM DESIRED SURFACE TEMPERATURE RISE BETWEEN TIME STEPS =   75.0 DEG R

MINIMUM EXPLICIT NODAL SPACING USED IN TIME STEP COMPUTATION =  0.0550 INCH
```

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

SAMPLE
PAGE 7

--- MATERIAL FLAG INDEX ---

```
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
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2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
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2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
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2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
1 1 1 1 1 1 1 1 1 1 1 1 1 1 3 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
1 1 1 1 1 1 1 1 1 1 1 1 3 3 3 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
1 1 1 1 1 1 1 1 1 1 1 3 3 3 3 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
```

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

SAMPLE
PAGE 8

---MATERIAL PROPERTIES---

••••••• M A T E R I A L   N U M B E R   1 •••••••

--- SURFACE ROUGHNESS ---

ROUGHNESS HEIGHT FOR TRANSITION	K-LAM = 10.000	(MIL)
ROUGHNESS HEIGHT FOR TURBULENT HEATING	K-TURB = 0.000	(MIL)
LAMINAR HEATING AUGMENTATION FLAG	JROUGH = 1	

--- PARAMETERS IN BLOWING CORRECTION TO TRANSFER COEFFICIENTS ---

LAMINAR SHEAR PARAMETER	(BLS) =	0.5000
LAMINAR HEATING PARAMETER	(BLH) =	0.5000
TURBULENT SHEAR PARAMETER	(BTS) =	0.3500
TURBULENT HEATING PARAMETER	(BTH) =	0.3500

--- THERMAL PROPERTIES ---

MATERIAL DENSITY	(RHO) =	418.08 (LBM/FT3)
DATUM TEMP FOR HEAT OF FORMATION	(TFO) =	536.00 (DEG R)
HEAT OF FORMATION	(HFO) =	0.00 (BTU/LBM)

TEMPERATURE (DEG R)	SPECIFIC HEAT (BTU/LB-DEG)	CONDUCTIVITY (BTU/FT-SEC-DEG)	SENSIBLE ENTHALPY (BTU/LB)	EMISSIVITY
400.00	0.0830	0.0179400	-11.81	0.1500
500.00	0.0880	0.0180500	-3.26	0.1500
600.00	0.0930	0.0179000	5.79	0.1500
700.00	0.0980	0.0175800	15.34	0.1500
800.00	0.1030	0.0171800	25.39	0.1500
900.00	0.1080	0.0167000	35.94	0.1500
1000.00	0.1120	0.0161800	46.94	0.1500
1100.00	0.1170	0.0156300	58.39	0.1500
1200.00	0.1220	0.0150600	70.34	0.1500

--- EROSION LAW MATERIAL FLAG ---

NERODE = 0

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

******* M A T E R I A L   N U M B E R   2 *******

--- SURFACE ROUGHNESS ---

```
ROUGHNESS HEIGHT FOR TRANSITION                 K-LAM  =  10.000  (MIL)
ROUGHNESS HEIGHT FOR TURBULENT HEATING          K-TURB =   0.000  (MIL)

LAMINAR HEATING AUGMENTATION FLAG               JROUGH =  1
```

--- PARAMETERS IN BLOWING CORRECTION TO TRANSFER COEFFICIENTS ---

```
LAMINAR SHEAR PARAMETER        (BLS) =  0.5000
LAMINAR HEATING PARAMETER      (BLH) =  0.5000
TURBULENT SHEAR PARAMETER      (BTS) =  0.3500
TURBULENT HEATING PARAMETER    (BTH) =  0.3500
```

--- THERMAL PROPERTIES ---

```
MATERIAL DENSITY                      (RHO) =   490.00 (LBM/FT3)
DATUM TEMP FOR HEAT OF FORMATION      (TFO) =   536.00 (DEG R)
HEAT OF FORMATION                     (HFO) =     0.00 (BTU/LBM)
```

TEMPERATURE (DEG R)	SPECIFIC HEAT (BTU/LB-DEG)	CONDUCTIVITY (BTU/FT-SEC-DEG)	SENSIBLE ENTHALPY (BTU/LB)	EMISSIVITY
492.00	0.1100	0.0073600	-4.84	0.6000
672.00	0.1100	0.0722000	14.96	0.6000
1032.00	0.1100	0.0694000	54.56	0.6000
1392.00	0.1100	0.0061100	94.16	0.6000

--- EROSION LAW MATERIAL FLAG ---

NERODE = 0

```
BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

******* M A T E R I A L   N U M B E R   3 *******

--- SURFACE ROUGHNESS ---

ROUGHNESS HEIGHT FOR TRANSITION              K-LAM  =   0.000  (MIL)
ROUGHNESS HEIGHT FOR TURBULENT HEATING       K-TURB =   0.000  (MIL)

LAMINAR HEATING AUGMENTATION FLAG            JROUGH =   1

--- PARAMETERS IN BLOWING CORRECTION TO TRANSFER COEFFICIENTS ---

        LAMINAR SHEAR PARAMETER        (BLS) =  0.5000
        LAMINAR HEATING PARAMETER      (BLH) =  0.5000
        TURBULENT SHEAR PARAMETER      (BTS) =  0.3500
        TURBULENT HEATING PARAMETER    (BTH) =  0.3500

--- THERMAL PROPERTIES ---

    MATERIAL DENSITY                    (RHO) =   488.80 (LBM/FT3)
    DATUM TEMP FOR HEAT OF FORMATION    (TFO) =   536.00 (DEG R)
    HEAT OF FORMATION                   (HFO) =     0.00 (BTU/LBM)
    LATENT HEAT OF FUSION            (XLATHT) =   117.00 (BTU/LBM)
    MELT TEMPERATURE                  (TMELT) =  3310.00 (DEG R)
    TEMP DIFFERENCE MELT OCCURS      (DTMELT) =    50.00 (R DEG)
    SPECIFIC HEAT OF SOLID           (CPSOLD) = 1.280E-01 (BTU/LBM-DEG R)
    SPECIFIC HEAT OF LIQUID          (CPLIQD) = 1.932E-01 (BTU/LBM-DEG R)

TEMPERATURE   SPECIFIC HEAT   CONDUCTIVITY      SENSIBLE    EMISSIVITY
                                                ENTHALPY
 (DEG R)      (BTU/LB-DEG)    (BTU/FT-SEC-DEG)  (BTU/LB)
  540.00        0.1280          0.0075600          0.51      0.5000
 3250.00        0.1280          0.0075600        347.39      0.5000
 3285.00        0.1280          0.0048300        351.87      0.5000
 3335.00        4.5520          0.0021000        468.87      0.5000
 3336.00        0.1932          0.0021000        471.24      0.5000
 9000.00        0.1932          0.0021000       1565.53      0.5000

--- EROSION LAW MATERIAL FLAG ---

          NERODE =  0
```

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

SAMPLE
PAGE 11

CONTACT RESISTANCES

MAT1	MAT2	RESISTANCE (Ft**2-S-DegR/BTU)
1	2	1.00000E-05
1	3	1.00000E-04
2	3	1.00000E-06

---SURFACE EQUILIBRIUM DATA---

MAT = 1
CMH = 1.00000

MASS TRANSFER COEF = 0.0000 LBM/FT**2-SEC PRESSURE = 1.0000 ATM

TEMP	BPRIM	HCH	TSEN	TCHEM	SPECIE
360.0000	0.0000	-15.2280	-75.8340	75.8346	AIR
536.4000	0.0001	0.0362	0.0000	0.0000	AIR
1080.0000	0.0010	56.1020	134.1990	-134.2771	AIR
1176.9984	0.0100	67.5933	103.9770	-159.4928	AC41
1181.9988	1.0000	68.1909	104.5566	-196.7961	AC41
1186.9992	10.0000	68.7884	105.1344	-525.1900	AC41
1191.9780	99.0000	69.3834	105.7392	-3778.4279	AC41

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

SAMPLE
PAGE 13

---SURFACE EQUILIBRIUM DATA---

MAT = 2
CMH = 1.00000

MASS TRANSFER COEF = 0.0000 LBM/FT**2-SEC PRESSURE = 1.0000 ATM

TEMP	BPRIM	HCH	TSEN	TCHEM	SPECIE
360.0000	0.0000	-19.3600	-75.8340	75.8346	AIR
530.4000	0.0001	0.0440	0.0000	0.0000	AIR
1080.0000	0.0010	59.8400	134.1990	-134.2734	AIR
4500.0000	6.9100	436.0400	945.1728	-950.2641	AIR

BRL IMPROVED ARRES SHAPE CHANGE CODE (BRLASCC)

---SURFACE EQUILIBRIUM DATA---

MAT = 3
CMH = 1 00000

MASS TRANSFER COEF = 0 0000 LBM/FT**2-SEC PRESSURE = 1 0000 ATM

TEMP	BPRIM	HCH	TSEN	TCHEM	SPECIE
360 0000	0 0000	-22 5280	-75 8340	75 8345	AIR
536 4000	0 0001	0 0512	0 0000	0.0000	AIR
1080 0000	0 0010	69 6320	134 1990	-134 2636	AIR
4500 0000	0 0100	696 1294	945 1728	-947 6632	AIR

--- ENVIRONMENT HISTORY FOR THE INITIAL BODY SHAPE ---

TIME (SEC)	--- FREESTREAM QUANTITIES --- VELOCITY (FT/SEC)	TEMPERATURE (DEG R)	PRESSURE (ATM)	--- SONIC POINT QUANTITIES --- TRANSITION PARAMETER	--- STAGNATION POINT QUANTITIES --- PRESSURE (ATM)	ENTHALPY (BTU/LBM)	HEAT TRANS. COEF. (LBM/FT2-SEC)
0.000	5259.0	520.000	1.0000E+00	6470.78	2.9143E+01	552.4	1.674
0.200	5184.0	520.000	1.0000E+00	6350.23	2.8333E+01	536.8	1.611
0.400	5082.0	520.000	1.0000E+00	6186.60	2.7250E+01	515.9	1.574
0.600	4941.0	520.000	1.0000E+00	5959.44	2.5780E+01	487.7	1.523
0.800	4793.0	520.000	1.0000E+00	5706.09	2.4203E+01	458.9	1.468
1.000	4636.0	520.000	1.0000E+00	5457.58	2.2677E+01	429.3	1.412
1.200	4446.0	520.000	1.0000E+00	5158.48	2.0897E+01	394.9	1.345
1.400	4249.0	520.000	1.0000E+00	4850.47	1.9131E+01	360.7	1.277
1.600	4035.0	520.000	1.0000E+00	4524.08	1.7304E+01	325.3	1.203
1.800	3839.0	520.000	1.0000E+00	4231.03	1.5714E+01	294.4	1.136
2.000	3629.0	520.000	1.0000E+00	3896.28	1.4012E+01	263.1	1.062

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.0000 SEC SAMPLE PAGE 16

SUMMARY
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ENVIRONMENT NO (NT)	SHAPE NO (MT)	TIME SEC (TIMEP)
1	1	0 0000

FREESTREAM MACH NO (AMACH)	FREESTREAM UNIT RE NO 1/FT (URI)	STAGNATION PT ENTHALPY BTU/LBM (HT2)	STAGNATION PT PRESSURE ATM (PT2)	ISENTROPIC EXPONENT BEHIND SHOCK (GAM2)	NOSE RADIUS INCH (RN)	INVISCID SONIC STREAM LENGTH INCH (SSONIC)
4 70	3 3127E+07	55[illegible] 4	29 143	1 310	0 1988	0 1468

STAGNATION POINT

SURFACE TEMPERATURE DEG R (TSTAGP)	RECESSION INCH (ZSTAGP)	HEAT TRANSFER COEFFICIENT LBM/FT2-SEC (RUCH(1))	CURVED SHOCK HEAT TRANSFER AUG (HETAUG)	TRANS PROXIMITY HEAT TRANSFER AUG (RUFSMT(1))	ROUGHNESS HEIGHT MIL (RUF(1))
585 0	0 0000	6 5948	1.0035	3.7132	10.0000

NOSETIP DRAG COEF NORM BY RN**2 (CDRAG)	SONIC STREAM LENGTH INCH (SSTR)	SONIC UNIT REYNOLDS NO 1/FT (URESTR)	AXIAL RECESSION AT R = 0 24 INCH INCH (ZSIDE)	TRANSITION STREAM LENGTH INCH (STRAN)
1 096	0 1504	1 9539E+07	0 0000	[illegible]298E-01

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.0000 SEC   SAMPLE PAGE 17

BODY SHAPE AND INVISCID FLOW INFORMATION

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	AXIAL LENGTH INCH (Z)	RADIAL LENGTH INCH (R)	BODY ANGLE DEG (THETB)	PRESSURE RATIO (PEPI)	SHOCK PT NO (L)	SHOCK AXIAL LENGTH INCH (XSHC)	SHOCK RADIAL LENGTH INCH (YSHC)	SHOCK ANGLE DEG (BETA)	ENTROPY BEHIND SHOCK BTU/LBM-DEG R (SRB)
1	1	0.0000	0.4507	0.0000	90.00	1.000000	1	0.4164	0.0000	90.00	1.82363
2	8	0.0694	0.4627	0.0684	70.02	0.873116	8	0.4324	0.0794	73.98	1.81213
3	15	0.1390	0.4975	0.1286	49.97	0.579113	15	0.4667	0.1545	60.94	1.78663
4	24	0.2675	0.6074	0.1953	23.87	0.192472	24	0.5649	0.2914	53.94	1.76707
5	28	0.4648	0.8000	0.2380	12.49	0.091220	28	0.7409	0.5045	44.36	1.73423
6	32	0.6697	1.0000	0.2823	12.50	0.082316	32	0.9153	0.6646	37.39	1.70818
7	37	0.9247	1.2490	0.3375	10.45	0.067667	37	1.1566	0.8385	31.28	1.68426
8	43	1.2287	1.5500	0.3798	8.00	0.056770	43	1.4611	1.0121	26.21	1.66532
9	49	1.5821	1.9000	0.4290	8.00	0.053958	49	1.7962	1.1677	22.27	1.65266
10	67	2.6929	3.0000	0.5836	8.00	0.051144	67	2.8654	1.5414	16.43	1.64103
11	83	3.7027	4.0000	0.7241	8.00	0.050353	83	3.8465	1.8166	14.92	1.63979
12	107	5.2175	5.5000	0.9349	8.00	0.050131	107	5.3212	2.2067	14.80	1.63973
13	131	6.7322	7.0000	1.1458	8.00	0.050808	131	6.7961	2.5963	14.80	1.63973

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0 0000 SEC　　SAMPLE PAGE 18

VISCOUS FLOW - EDGE PROPERTIES
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BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	VELOCITY FT/SEC (UE)	MACH NO (HCAM)	ENTHALPY BTU/LBM (HE)	TEMPERATURE DEG R (TE)	DENSITY LBM/FT3 (ROE)	VISCOSITY LBM/FT-SEC (VISE)	UNIT RE NO 1/FT (URE)
1	1	0 0000	0 0	0 0000	552 4	2580 6	4.462E-01	3.603E-05	0 000E+00
2	8	0 0694	1110 7	0 4679	527 8	2496 4	4 027E-01	3 525E-05	1.269E+07
3	15	0 1390	2161 6	0 9548	459 1	2259 3	2.952E-01	3 301E-05	1.933E+07
4	24	0 2675	3515 0	1 [illegible]	305 7	1714 3	1.293E-01	2 752E-05	1.651E+07
5	28	0 4648	4079 5	2 2630	220 1	1394 4	7.533E-02	2 401E-05	1.280E+07
6	32	0 6697	4177 5	2 3561	203 0	1332 4	7.114E-02	2.331E-05	1.275E+07
7	37	0 9247	4285 8	2 4890	185 6	1262 0	6.174E-02	2 249E-05	1.177E+07
8	43	1 2287	4389 7	2 6170	167 6	1192 6	5.482E-02	2.166E-05	1.111E+07
9	49	1 5821	4444 8	2 6895	157 9	1155 0	5.380E-02	2.121E-05	1.127E+07
10	67	2 6929	4575 6	2 8774	134 3	1063 5	5.538E-02	2.009E-05	1.261E+07
11	83	3 7027	4629 4	2 9620	124 4	1025 0	5 657E-02	1 961E-05	1.336E+07
12	107	5 2175	4671 9	3 0324	116 5	994 2	5 806E-02	1 921E-05	1.412E+07
13	131	6 7322	4706 1	3.0914	110 1	969 2	6.036E-02	1 889E-05	1.504E+07

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.0000 SEC

SAMPLE
PAGE 19

VISCOUS FLOW - WALL AND B. L. RECOVERY PROPERTIES

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	WALL TEMPERATURE DEG R (TW)	WALL ENTHALPY BTU/LBM (HW)	WALL DENSITY LBM/FT3 (ROW)	WALL VISCOSITY LBM/FT-SEC (VISW)	RECOVERY ENTHALPY BTU/LBM (HR)	RECOVERY FACTOR (RECOV)	SENSBL CONV HEAT FLUX BTU/FT2-SEC	CF/2
1	1	0.0000	585.0	15.7	1.968E+00	1.320E-05	552.4	0.8367	3.540E+03	1.000E+30
2	8	0.0694	585.0	15.7	1.719E+00	1.320E-05	549.6	0.8849	4.077E+03	3.884E-02
3	15	0.1390	585.0	15.7	1.140E+00	1.320E-05	541.9	0.8872	3.896E+03	2.613E-02
4	24	0.2675	585.0	15.7	3.789E-01	1.320E-05	524.7	0.8875	1.631E+03	1.552E-02
5	28	0.4648	585.0	15.7	1.796E-01	1.320E-05	515.0	0.8875	6.570E+02	8.267E-03
6	32	0.6697	585.0	15.7	1.620E-01	1.320E-05	513.2	0.8875	5.683E+02	6.965E-03
7	37	0.9247	585.0	15.7	1.332E-01	1.320E-05	511.2	0.8875	4.488E+02	5.904E-03
8	43	1.2287	585.0	15.7	1.117E-01	1.320E-05	509.2	0.8876	3.603E+02	5.028E-03
9	49	1.5821	585.0	15.7	1.062E-01	1.320E-05	508.1	0.8876	3.342E+02	4.578E-03
10	67	2.6929	585.0	15.7	1.007E-01	1.320E-05	505.5	0.8877	3.027E+02	3.766E-03
11	83	3.7027	585.0	15.7	9.912E-02	1.320E-05	504.4	0.8878	2.886E+02	3.408E-03
12	107	5.2175	585.0	15.7	9.868E-02	1.320E-05	503.5	0.8878	2.758E+02	3.087E-03
13	131	6.7322	585.0	15.7	1.000E-01	1.320E-05	502.8	0.8878	2.709E+02	2.868E-03

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.0000 SEC SAMPLE PAGE 20

VISCOUS FLOW - BOUNDARY LAYER SOLUTION

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BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	MOMENTUM THICKNESS MIL (THE)	ENERGY THICKNESS MIL (PHI)	SHAPE FACTOR (HSF)	MOM THICK RE NO (RETH)	ENERGY THICK RE NO (REPH)	HEAT TRANS COEFFICIENT LBM/FT2-SEC (RUCH)	REYNOLDS ANAL FAC (RAF)	INTER-MITTENCY (ADML)	TRANSITION PARAMETER (TP)
1	1	0.0000	0.302	0.465	0.073	0.000E+00	0.000E+00	6.595E+00	1.0035	0.00	0.000
2	8	0.0694	0.635	0.529	0.892	6.712E+02	5.591E+02	7.636E+00	0.4395	0.94	0.000
3	15	0.1390	1.023	0.845	1.148	1.648E+03	1.361E+03	7.403E+00	0.4440	0.99	0.000
4	24	0.2675	1.779	1.972	2.172	2.448E+03	2.714E+03	3.203E+00	0.4542	0.99	0.000
5	28	0.4648	3.188	3.553	2.876	3.400E+03	3.789E+03	1.316E+00	0.5179	0.99	0.000
6	32	0.6697	3.939	3.814	3.024	4.185E+03	4.053E+03	1.142E+00	0.5518	0.99	0.000
7	37	0.9247	4.855	4.411	3.206	4.761E+03	4.326E+03	9.058E-01	0.5798	0.99	0.000
8	43	1.2287	5.908	5.199	3.406	5.469E+03	4.813E+03	7.302E-01	0.6036	0.99	0.000
9	49	1.5821	6.667	5.529	3.524	6.263E+03	5.194E+03	6.787E-01	0.6201	0.99	0.000
10	67	2.6929	8.182	6.068	3.870	8.599E+03	6.378E+03	6.180E-01	0.6477	1.00	0.000
11	83	3.7027	9.436	6.644	4.017	1.050E+04	7.395E+03	5.906E-01	0.6618	1.00	0.000
12	107	5.2175	11.224	7.562	4.126	1.321E+04	8.898E+03	5.654E-01	0.6752	1.00	0.000
13	131	6.7322	12.699	8.352	4.225	1.592E+04	1.047E+04	5.561E-01	0.6825	1.00	0.000

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.0000 SEC SAMPLE PAGE 21

VISCOUS FLOW - CURVED SHOCK AND ROUGHNESS EFFECTS

BODY PT NO (J)	INTEG PT NO (I)	STREAM LENGTH INCH (S)	CURVED SHOCK EFFECTS: EDGE ENTROPY BTU/LBM-DEG R (ENTR)	CURVED SHOCK EFFECTS: EDGE STREAMLINE LOCATION AT SHOCK INCH (YBAR)	CURVED SHOCK EFFECTS: EDGE MASS FLUX AUGMENTATION (ROUE)	SURFACE ROUGHNESS EFFECTS: ROUGHNESS MIL (RUF)	SURFACE ROUGHNESS EFFECTS: HEAT TRANSFER AUGMENTATION (RUFSMT)	SURFACE ROUGHNESS EFFECTS: ROUGHNESS REYNOLDS NO (REKP)
1	1	0.0000	1.82363	0.0000	1.0000	[illegible]	[illegible].7132	0.000E+00
2	8	0.069[illegible]	1.82323	0.0139	1.0220	10.0000	[illegible].0590	1.150E+04
3	15	0.1390	1.82245	0.0316	1.0191	10.0000	[illegible].0977	1.280E+04
4	24	0.2675	1.82089	0.0481	1.0195	10.0000	2.[illegible]494	6.120E+03
5	28	0.4648	1.81749	0.0635	1.0380	10.0000	2.[illegible]	2.725E+03
6	32	0.6697	1.81290	0.0773	1.0656	10.0000	2.[illegible]	2.363E+03
7	37	0.9247	1.81245	0.0905	1.0659	10.0000	2.1[illegible]	1.886E+03
8	43	1.2287	1.81003	0.1031	1.0783	10.0000	2.0649	1.538E+03
9	49	1.5821	1.80531	0.1175	1.1054	10.0000	2.0226	1.435E+03
10	67	2.6929	1.78783	0.1602	1.2108	10.0000	1.9558	1.324E+03
11	83	3.7027	1.77945	0.1974	1.2635	10.0000	1.9226	1.277E+03
12	107	5.2175	1.77193	0.2522	1.3124	10.0000	1.8910	1.240E+03
13	131	6.7322	1.76448	0.3068	1.3630	10.0000	1.8721	1.236E+03

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

SAMPLE
TIME = 0.0000 SEC PAGE 22

--- INITIAL CONDUCTION TIME STEPS ---

TIME STEP TO NEXT USER SPECIFIED TIME SEC (DLTOUT)	TIME STEP TO PRODUCE DESIRED SURFACE TEMPERATURE CHANGE SEC (DLTIS)	EXPLICIT STABILITY TIME STEP SEC (DLTC)
1.0000E-02	3.5475E-04	6.9277E-03

- - - - - - - - - - - - - - CONDUCTION TIME STEPS COMPUTED - - - - - - - - - - - - - -

SHAPE NO	TIME	STAG PT RECESS	STAG PT REC RATE	STAG PT TEMP	TIME STEP USED	NEXT SPEC PRINT TIME	EXPLICIT STABILITY	HEAT FLUX CHANGE	SURF TEMP CHANGE	LAT COND STABILITY	HALF IMPLICIT NODE THICKNESS
	(SEC)	(INCH)	(IN/SEC)	(DEG R)	(SEC)	(SEC)	(SEC)	(SEC)	(SEC)	(SEC)	(SEC)
2	0.00	0.451	2.908E-05	637.8	3.547E-04	1.000E-02	6.928E-03	0.000E+00	0.000E+00	1.491E-02	3.428E+02
3	0.00	0.451	3.540E-05	684.2	4.141E-04	9.645E-03	6.758E-03	6.928E-03	4.141E-04	1.516E-02	2.737E+02
4	0.00	0.451	4.329E-05	731.7	5.734E-04	9.231E-03	6.621E-03	6.758E-03	5.734E-04	1.516E-02	2.183E+02
5	0.00	0.451	5.259E-05	777.7	7.359E-04	8.658E-03	6.489E-03	7.359E-04	7.900E-04	1.516E-02	1.759E+02
6	0.00	0.451	6.386E-05	823.6	9.444E-04	7.922E-03	6.366E-03	9.444E-04	1.062E-03	1.516E-02	1.421E+02

SURFACE TEMPERATURE AT BODY POINT 2 HAS CHANGED BY A FACTOR OF 1.40 ----- COMPUTE NEW ENVIRONMENT

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.0030 SEC SAMPLE PAGE 23

BODY POINT LOCATION AND SURFACE ENERGY BALANCE RESULTS

BODY PT NO (J)	AXIAL LENGTH INCH (ZSP)	RADIAL LENGTH INCH (RSP)	SURFACE TEMP DEG R (TSP)	TOTAL RECESS RATE IN/SEC (SDOT)	EROSION RECESS RATE IN/SEC (SDOTE)	B-PRIME THERMOCHEM (BPSP)	EROSION MASS LOSS RATE LBM/SEC-FT2 (EMDOT)	HEAT TRANS COEFFICIENT LBM/FT2-SEC (RUCHSP)	RECOVERY ENTHALPY BTU/LBM (HRSP)	SURFACE PRESSURE ATM (PRESP)
1	0.4507	0.0000	823.6	0.0001	0.0000	3.375E-04	0.0000	6.591E+00	552.2	29.1306
2	0.4627	0.0684	854.9	0.0001	0.0000	3.854E-04	0.0000	7.631E+00	549.4	25.4344
3	0.4975	0.1286	845.4	0.0001	0.0000	3.702E-04	0.0000	7.398E+00	541.7	16.8699
4	0.6074	0.1953	700.3	0.0000	0.0000	2.002E-04	0.0000	3.202E+00	524.5	5.6068
5	0.8000	0.2380	632.7	0.0000	0.0000	1.504E-04	0.0000	1.315E+00	514.8	2.6573
6	1.0000	0.2823	626.0	0.0000	0.0000	1.462E-04	0.0000	1.141E+00	513.0	2.3979
7	1.2490	0.3375	616.7	0.0000	0.0000	1.405E-04	0.0000	9.053E-01	511.0	1.9712
8	1.5500	0.3798	610.1	0.0000	0.0000	1.366E-04	0.0000	7.298E-01	509.0	1.6537
9	1.9000	0.4290	598.3	0.0000	0.0000	1.300E-04	0.0000	6.783E-01	507.9	1.5718
10	3.0000	0.5836	597.0	0.0000	0.0000	1.293E-04	0.0000	6.177E-01	505.3	1.4899
11	4.0000	0.7241	596.4	0.0000	0.0000	1.289E-04	0.0000	5.902E-01	504.2	1.4668
12	5.5000	0.9349	595.9	0.0000	0.0000	1.286E-04	0.0000	5.651E-01	503.3	1.4603
13	7.0000	1.1458	595.7	0.0000	0.0000	1.285E-04	0.0000	5.558E-01	502.6	1.4801

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.0030 SEC   S*MPLE PAGE 24

SUMMARY
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ENVIRONMENT NO	SHAPE NO	TIME SEC
(NT)	(MT)	(TIMEP)
2	6	0.0030

FREESTREAM MACH NO	FREESTREAM UNIT RE NO 1/FT	STAGNATION PT ENTHALPY BTU/LBM	STAGNATION PT PRESSURE ATM	ISENTROPIC EXPONENT BEHIND SHOCK	NOSE RADIUS INCH	INVISCID SONIC STREAM LENGTH INCH
(AMACH)	(UR1)	(HT2)	(PT2)	(GAM2)	(RN)	(SSONIC)
4 69	3 3120E+07	552 2	29 131	1.310	0.1949	0.1267

STAGNATION POINT

SURFACE TEMPERATURE DEG R	RECESSION INCH	HEAT TRANSFER COEFFICIENT LBM/FT2-SEC	CURVED SHOCK HEAT TRANSFER AUG	TRANS PROXIMITY HEAT TRANSFER AUG	ROUGHNESS HEIGHT MIL
(TSTAGP)	(ZSTAGP)	(RUCH(1))	(HETAUG)	(RUFSMT(1))	(RUF(1))
823 6	0 0000	6 6835	1 0037	3.7718	10.0000

NOSETIP DRAG COEF NORM BY RN1**2	SONIC STREAM LENGTH INCH	SONIC UNIT REYNOLDS NO 1/FT	AXIAL RECESSION AT R = 0.24 INCH INCH	TRANSITION STREAM LENGTH INCH
(CDRAG)	(SSTR)	(URESTR)	(ZSIDE)	(STRAN)
0 996	0 1287	1 9596E+07	0.0000	298E-01

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

SAMPLE
TIME = 0.0030 SEC PAGE 25

- - - - - - - - - - - - - - - CONDUCTION TIME STEPS COMPUTED - - - - - - - - - - - - - -

SHAPE NO	TIME	STAG PT RECESS	STAG PT REC RATE	STAG PT TEMP	TIME STEP USED	NEXT SPEC PRINT TIME	EXPLICIT STABILITY	HEAT FLUX CHANGE	SURF TEMP CHANGE	LAT COND STABILITY	HALF IMPLICIT NODE THICKNESS
	(SEC)	(INCH)	(IN/SEC)	(DEG R)	(SEC)	(SEC)	(SEC)	(SEC)	(SEC)	(SEC)	(SEC)
7	0.00	0.451	1.097E-01	899.9	1.379E-03	6.977E-03	6.246E-03	1.964E-03	1.379E-03	1.516E-02	1.393E+02
8	0.01	0.451	6.963E-05	948.6	1.770E-03	5.598E-03	6.105E-03	1.770E-03	2.535E-03	1.490E-02	1.142E+02
9	0.01	0.451	8.550E-05	1003.2	2.271E-03	3.828E-03	5.963E-03	2.271E-03	2.762E-03	1.491E-02	9.125E+01
10	0.01	0.451	2.016E-04	1037.5	1.557E-03	1.557E-03	5.815E-03	2.915E-03	3.154E-03	1.493E-02	7.925E+01

TEMPERATURES IN SURFACE LAYER, DEG R (TT)

	SURFACE MATERIAL INDEX	1	2	3	4	5	6	7	8	9	10	11
1	1	1037.5	884.3	776.2	701.2	654.1	623.7	607.1	596.4	591.9	588.6	588.8
2	1	1028.1	885.5	784.1	711.4	664.9	632.9	615.0	602.2	596.7	591.6	591.1
3	1	1000.0	875.0	785.4	718.0	674.1	641.3	622.6	607.6	601.1	594.2	593.3
4	1	770.6	723.1	689.5	661.2	642.8	626.2	616.7	607.1	602.9	597.3	596.3
5	1	672.7	652.9	638.9	625.7	617.2	608.6	603.9	598.4	596.2	592.8	592.0
6	1	661.5	642.2	627.8	615.4	607.1	599.9	595.7	591.9	590.2	588.2	587.9
7	1	644.4	625.1	611.2	601.2	594.9	590.6	588.3	586.7	586.0	585.4	585.3
8	1	632.7	615.8	604.0	596.1	591.2	588.3	586.8	585.8	585.5	585.2	585.1
9	2	610.3	603.9	598.9	595.3	592.2	588.9	587.2	586.0	585.6	585.2	585.1
10	2	607.6	601.5	596.7	592.8	590.2	588.2	587.0	586.1	585.7	585.3	585.2
11	2	606.5	600.7	596.0	592.4	589.9	588.0	586.9	586.1	585.7	585.3	585.3
12	2	605.6	599.9	595.5	592.0	589.6	587.8	586.8	586.0	585.7	585.3	585.2
13	2	605.2	599.7	595.3	591.8	589.5	587.7	586.8	586.0	585.6	585.3	585.2

SURFACE LAYER NODELET MATERIAL INDICES (IMAT)

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4	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1
9	2	2	2	2	1	1	1	1	1	1	2
10	2	2	2	2	2	2	2	2	2	2	2
11	2	2	2	2	2	2	2	2	2	2	2
12	2	2	2	2	2	2	2	2	2	2	2
13	2	2	2	2	2	2	2	2	2	2	2

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

SAMPLE

TIME = 0 0100 SEC PAGE 27

INTERNAL EXPLICIT NODE FLAGS (NREG)

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19  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 0 0 0 0 0 0 0 1 1 1
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16  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1
15  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
14  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
13  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
12  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
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10  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 9  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 8  2 2 2 2 2 2 2 2 2 2 2 2 2 2 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 7  2 2 2 2 2 2 2 2 2 2 2 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 6  2 2 2 2 2 2 2 2 2 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 5  2 2 2 2 2 2 2 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 4  2 2 2 2 2 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 3  2 2 2 2 2 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 2  2 2 2 2 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 1  2 2 2 2 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
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INTERNAL EXPLICIT NODE MATERIAL INDICES (NMAT)

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   605958575655545352515049484746454443424140393837363534333231302928272625242322212019181716151413121110 9 8 7 6 5 4 3 2 1
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19  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
18  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
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16  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
15  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
14  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
13  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
12  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
11  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
10  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
 9  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
 8  1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
 7  1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
 6  1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
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BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.0100 SEC SAMPLE PAGE 28

TEMPERATURES IN INTERNAL EXPLICIT GRID,DEG R (T)

	60	56	52	48	44	40	36	32	28	24	20	16	12	8	4
	59	55	51	47	43	39	35	31	27	23	19	15	11	7	3
	58	54	50	46	42	38	34	30	26	22	18	14	10	6	2
	57	53	49	45	41	37	33	29	25	21	17	13	9	5	1
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	599.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	593.8
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	589.9
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	589.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	605.0	587.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	597.8	586.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	592.4	585.5
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	591.3	585.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	588.4	585.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	602.8	586.7	585.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	596.0	585.8	585.1
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	594.5	585.7	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	590.4	585.3	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	587.7	585.2	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	600.5	586.4	585.1	585.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	598.7	586.1	585.1	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	593.1	585.6	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	589.5	585.3	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	587.3	585.2	585.0	585.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	604.1	586.9	585.1	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	597.0	585.9	585.1	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	591.8	585.4	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	588.8	585.3	585.0	585.0	585.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	588.1	585.3	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	601.9	586.6	585.1	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	595.4	585.8	585.1	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	590.9	585.3	585.0	585.0	585.0	585.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	590.0	585.3	585.6	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	587.6	585.2	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	599.9	586.3	585.1	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	594.0	585.6	585.0	585.0	585.0	585.0	585.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	592.6	585.5	585.0	585.0	585.0	585.0	585.0

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

SAMPLE

TIME = 0.0100 SEC PAGE 29

	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	589.2	585.3	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	605.8	587.2	585.2	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	598.2	586.0	585.1	585.0	585.0	585.0	585.0	585.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	596.5	585.9	585.1	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	591.6	585.4	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	588.5	585.3	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	603.7	586.8	585.1	585.0	585.0	585.0	585.0	585.0	585.0
11	0.0	0.0	0.0	0.0	0.0	0.0	601.7	586.5	585.1	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	595.1	585.7	585.0	585.0	585.0	585.0	585.0	585.6	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	590.7	585.3	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	0.0	587.9	585.3	585.0	585.0	585.0	585.0	585.0	585.0	585.0
10	0.0	0.0	0.0	0.0	0.0	608.8	587.5	585.2	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	600.4	586.1	585.1	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	594.3	585.6	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	0.0	590.2	585.3	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
9	0.0	0.0	0.0	0.0	0.0	589.6	585.4	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	607.0	587.1	585.2	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	599.1	585.9	585.1	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	593.7	585.4	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
8	0.0	0.0	0.0	0.0	593.2	585.2	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	0.0	588.7	585.3	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	613.5	586.6	585.1	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	599.2	585.7	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
7	0.0	0.0	0.0	599.8	585.5	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	591.0	585.2	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	0.0	587.7	585.2	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	617.6	586.1	585.1	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
6	0.0	0.0	0.0	585.9	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	617.6	585.3	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	594.9	585.3	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	587.3	585.1	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
5	0.0	0.0	595.4	585.1	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	588.6	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	0.0	586.1	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	618.8	585.2	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
4	0.0	0.0	586.1	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	704.8	585.3	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	596.1	585.1	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	589.3	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
3	0.0	0.0	585.1	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	597.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	586.3	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0
	0.0	585.3	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0	585.0

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.0100 SEC SAMPLE PAGE 30

```
2     0.0   846.8   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0
        0.0   592.9   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0
          0.0   585.2   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0
            0.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0

1     0.0   762.7   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0
        0.0   591.1   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0
          0.0   585.1   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0
            0.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0   585.0
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BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.0100 SEC SAMPLE PAGE 31

BODY POINT LOCATION AND SURFACE ENERGY BALANCE RESULTS
****

BODY PT NO (J)	AXIAL LENGTH INCH (ZSP)	RADIAL LENGTH INCH (RSP)	SURFACE TEMP DEG R (TSP)	TOTAL RECESS RATE IN/SEC (SDOT)	EROSION RECESS RATE IN/SEC (SDOTE)	B-PRIME THERMOCHEM (BPSP)	EROSION MASS LOSS RATE LBM/SEC-FT2 (EMDOT)	HEAT TRANS COEFFICIENT LBM/FT2-SEC (RUCHSP)	RECOVERY ENTHALPY BTU/LBM (HRSP)	SURFACE PRESSURE ATM (PRESP)
1	0.4509	0.0000	1037.5	0.0002*	0.0000	3.375E-04*	0.0000	6.677E+00	551.8	29.1084
2	0.4627	0.0684	1028.1	0.0002	0.0000	8.028E-04	0.0000	6.572E+00	548.8	25.2328
3	0.4975	0.1286	1000.0	0.0001	0.0000	7.127E-04	0.0000	6.228E+00	538.4	14.3756
4	0.6074	0.1953	770.6	0.0000	0.0000	2.697E-04	0.0000	2.686E+00	522.4	4.9021
5	0.8000	0.2330	672.7	0.0000	0.0000	1.781E-04	0.0000	1.275E+00	514.1	2.5578
6	1.0000	0.2823	661.5	0.0000	0.0000	1.699E-04	0.0000	1.116E+00	512.5	2.3310
7	1.2490	0.3375	644.4	0.0000	0.0000	1.580E-04	0.0000	8.833E-01	510.1	1.9055
8	1.5500	0.3798	632.7	0.0000	0.0000	1.504E-04	0.0000	7.220E-01	508.3	1.6210
9	1.9000	0.4290	610.3	0.0000	0.0000	1.367E-04	0.0000	6.806E-01	507.2	1.5508
10	3.0000	0.5836	607.6	0.0000	0.0000	1.352E-04	0.0000	6.406E-01	499.9	1.4831
11	4.0000	0.7241	606.5	0.0000	0.0000	1.346E-04	0.0000	6.146E-01	496.8	1.4626
12	5.5000	0.9349	605.6	0.0000	0.0000	1.340E-04	0.0000	5.935E-01	494.3	1.4623
13	7.0000	1.1458	605.2	0.0000	0.0000	1.338E-04	0.0000	5.870E-01	492.9	1.4897

SUMMARY
****

ENVIRONMENT NO (NT)	SHAPE NO (MT)	TIME SEC (TIMEP)
3	10	0.0100

FREESTREAM MACH NO (AMACH)	FREESTREAM UNIT RE NO 1/FT (UR1)	STAGNATION PT ENTHALPY BTU/LBM (HT2)	STAGNATION PT PRESSURE ATM (PT2)	ISENTROPIC EXPONENT BEHIND SHOCK (GAM2)	NOSE RADIUS INCH (RN)	INVISCID SONIC STREAM LENGTH INCH (SSONIC)
4.69	3.3104E+07	551.7	29.102	1.310	0.1954	0.1265

STAGNATION POINT					
SURFACE TEMPERATURE DEG R (TSTAGP)	RECESSION INCH (ZSTAGP)	HEAT TRANSFER COEFFICIENT LBM/FT2-SEC (RUCH(1))	CURVED SHOCK HEAT TRANSFER AUG (HETAUG)	TRANS PROXIMITY HEAT TRANSFER AUG (RUFSMT(1))	ROUGHNESS HEIGHT MIL (RUF(1))
1037.5	0.0002	6.6674	1.0038	3.8130	10.0000

NOSETIP DRAG COEF NORM BY RN1**2 (CDRAG)	SONIC STREAM LENGTH INCH (SSTR)	SONIC UNIT REYNOLDS NO 1/FT (URESTR)	AXIAL RECESSION AT R = 0.24 INCH INCH (ZSIDE)	TRANSITION STREAM LENGTH INCH (STRAN)
0.996	0.1286	1.9595E+07	0.0000	.298E-01

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BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)                                    SAMPLE
                                                         TIME =   0.4382 SEC      PAGE  62

                    *************
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                    R E S T A R T
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                    *************

                   FROM  NT =   7
                               ---

BRL FLIGHT CASE (YUMA  TS=125 DEG-F, T0=60 DEG-F)
SAMPLE TRANSIENT CONDUCTION SOLUTION -- BRLASCC
12 5 DEG NOSE  7 INCH BODY  -- 1 SEPTEMBER 1983     SAMPLE

 *** THE ORIGIN WAS CHANGED TO  2 0000E+00 INCH ***
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ORIGNAL IMPLICIT GRID

```
NB          1        2        2        2        2        2
IMAT        1        1        1        1        1        1        1        1        2        2        2
FI=      0.00
TT=   1185.20  1146.95  1125.70  1087.85  1071.96  1031.65  1020.12   974.38   968.52   954.11   947.42
XS=    0.5241   0.5231   0.5221   0.5211   0.5201   0.5191 [illegible] 0.5171 0.5161   0.5151   0.5141
YS=    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
NB          1        2        2        2        2        2
IMAT        1        1        1        1        1        1        1        2        2        2        2
FI=      0.07
TT=   1185.17  1146.18  1125.50  1087.99  1072.95  1034.11  1023.07   979.40   976.70   960.17   952.58
XS=    0.5235   0.5225   0.5215   0.5205   0.5195   0.5185   0.5175   0.5165   0.5155   0.5145   0.5135
YS=    0.0043   0.0042   0.0042   0.0041   0.0040   0.0040   0.0039   0.0038   0.0038   0.0037   0.0036
NB          1        2        2        2        2        2
IMAT        1        1        1        1        1        1        1        1        1        1        1
FI=      0.13
TT=   1185.07  1149.75  1125.17  1093.43  1073.49  1043.98  1027.55   999.27   987.01   963.41   955.08
XS=    0.5222   0.5212   0.5202   0.5193   0.5183   0.5173   0.5163   0.5153   0.5143   6.5133   0.5123
YS=    0.0082   0.0081   0.0079   0.0078   0.0077   0.0076   0.0074   0.0073   0.0072   0.0071   0.0069
NB          1        2        2        2        2        2
IMAT        1        1        1        1        1        1        1        1        1        1        1
FI=      0.22
TT=   1184.95  1150.87  1125.50  1096.05  1076.07  1048.92  1033.03  1006.76   994.40   967.99   958.86
XS=    0.5195   0.5185   0.5175   0.5165   0.5156   0.5146   0.5136   0.5126   0.5116   0.5107   0.5097
YS=    0.0134   0.0132   0.0129   0.0127   0.0125   0.0123   0.0121   0.0119   0.0117   0.0115   0.0112
NB          1        3        2        2        2        2
IMAT        1        1        1        1        1        1        1        1        1        1        1
FI=      0.33
TT=   1184.08  1154.42  1139.85  1110.21  1097.07  1067.46  1055.60  1025.88  1015.04   985.04   975.01
XS=    0.5156   0.5146   0.5137   0.5127   0.5118   0.5108   0.5099   0.5089   0.5080   0.5071   0.5061
YS=    0.0195   0.0191   0.0188   0.0185   0.0182   0.0179   0.0175   0.0172   0.0169   0.0166   0.0162
NB          1        3        2        2        2        2
IMAT        1        1        1        1        1        1        1        1        1        1        1
FI=      0.51
TT=   1055.68  1028.18  1018.17   991.63   982.26   956.63   947.84   923.11   914.83   890.97   883.16
XS=    0.5000   0.4991   0.4983   0.4974   0.4965   0.4956   0.4948   0.4939   0.4930   0.4922   0.4913
YS=    0.0235   0.0230   0.0225   0.0220   0.0216   0.0211   0.0206   0.0201   0.0196   0.0191   0.0186
NB          1        3        2        2        2        2
IMAT        1        1        1        1        1        1        1        1        1        1        1
FI=      0.93
TT=    970.91   945.77   936.19   912.07   903.20   880.02   871.84   849.55   842.01   820.53   813.57
XS=    0.4792   0.4787   0.4781   0.4775   0.4769   0.4763   0.4757   0.4751   0.4745   0.4739   0.4733
YS=    0.0281   0.0273   0.0265   0.0257   0.0249   0.0241   0.0233   0.0225   0.0217   0.0209   0.0201
NB          1        3        2        2        2        2
IMAT        1        1        1        1        1        1        1        1        1        1        1
FI=      1.57
TT=    882.46   861.54   853.53   833.29   825.86   806.17   799.22   780.07   773.57   754.90   748.80
XS=    0.4542   0.4542   0.4542   0.4542   0.4542   0.4542   0.4542   0.4542   0.4542   0.4542   0.4542
YS=    0.0316   0.0306   0.0296   0.0286   0.0276   0.0266   0.0256   0.0246   0.0236   0.0226   0.0216
NB          2        1        2        2        2        2
IMAT        2        2        2        2        1        1        1        1        1        1        2
FI=      1.57
TT=    819.09   814.57   812.54   808.24   804.79   787.06   780.50   763.73   758.08   742.11   738.66
XS=    0.4250   0.4250   0.4250   0.4250   0.4250   0.4250   0.4250   0.4250   0.4250   0.4250   0.4250
YS=    0.0357   0.0347   0.0337   0.0327   0.0317   0.0307   0.0297   0.0287   0.0277   0.0267   0.0257
NB          2        2        2        2        2        2
IMAT        2        2        2        2        2        2        2 [illegible]     2        2        2
FI=      1.57
TT=    718.44   713.73   711.88   707.30   705.57   701.11   699.49   695.13   693.64   689.38   688.01
XS=    0.3333   0.3333   0.3333   0.3333   0.3333   0.3333   0.3333   0.3333   0.3333   0.3333   0.3333
YS=    0.0486   0.0476   0.0466   0.0456   0.0446   0.0436   0.0426   0.0416   0.0406   0.0396   0.0386
NB          2        2        2        2        2        2
```

FI=	1.57										
TT=	696.63	691.87	690.14	685.43	683.76	679.12	677.51	672.93	671.37	666.72	665.18
XS=	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
YS=	0.0603	0.0593	0.0583	0.0573	0.0563	0.0553	0.0543	0.0533	0.0523	0.0513	0.0503
NB	2	2	2	2	2	2					
IMAT	2	2	2	2	2	2	2	2	2	2	2
FI=	1.57										
TT=	686.79	682.23	680.58	676.07	674.47	669.95	668.37	663.76	662.19	657.49	655.93
XS=	0.1250	0.1250	0.1250	0.1250	0.1250	0.1250	0.1250	0.1250	0.1250	0.1250	0.1250
YS=	0.0779	0.0769	0.0759	0.0749	0.0739	0.0729	0.0719	0.0709	0.0699	0.0689	0.0679
NB	2	2	2	2	2	2					
IMAT	2	2	2	2	2	2	2	2	2	2	2
FI=	1.57										
TT=	686.39	682.07	680.45	676.20	674.65	670.43	668.93	664.67	663.21	658.89	657.47
XS=	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
YS=	0.0955	0.0945	0.0935	0.0925	0.0915	0.0905	0.0895	0.0865	0.0875	0.0865	0.0855

SHIFTED IMPLICIT GRID

```
FI=     0.00
          ZI          RI          BLEN    NB      0.5167     0.0000     0.1000    2
          ZI          RI          BLEN    NB      0.5167     0.0000     0.1000    2
          ZI          RI          BLEN    NB      0.5167     0.0000     0.1000    2
          ZI          RI          BLEN    NB      0.5167     0.0000     0.1000    2
          ZI          RI          BLEN    NB      0.5167     0.0000     0.1000    2
NB            1          2          2          2          2          2
IMAT          1          1          1          1          1          1          1          1          2          2          2
TT=     1185.20    1146.95    1125.70    1087.85    1071.96    1031.65    1020.12     974.38     968.52     954.11     947.42
XS=      0.5241     0.5231     0.5221     0.5211     0.5201     0.5191     0.5181     0.5171     0.5161     0.5151     0.5141
YS=      0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
FI=     0.04
          ZI          RI          BLEN    NB      0.5167     0.0040     0.1001    2
          ZI          RI          BLEN    NB      0.5167     0.0040     0.1001    2
          ZI          RI          BLEN    NB      0.5167     0.0040     0.1001    2
          ZI          RI          BLEN    NB      0.5167     0.0040     0.1001    2
          ZI          RI          BLEN    NB      0.5167     0.0040     0.1001    2
NB            1          2          2          2          2          2
IMAT          1          1          1          1          1          1          1          2          2          2          2
TT=     1185.17    1146.18    1125.50    1088.89    1073.40    1035.87    1023.76     982.67     977.50     961.58     953.37
XS=      0.5235     0.5225     0.5215     0.5205     0.5195     0.5185     0.5175     0.5165     0.5155     0.5145     0.5135
YS=      0.0043     0.0043     0.0042     0.0042     0.0041     0.0041     0.0041     0.0040     0.0040     0.0039     0.0039
FI=     0.08
          ZI          RI          BLEN    NB      0.4998     0.0065     0.0834    2
          ZI          RI          BLEN    NB      0.4998     0.0065     0.0834    2
          ZI          RI          BLEN    NB      0.4998     0.0065     0.0834    2
          ZI          RI          BLEN    NB      0.4998     0.0065     0.0834    2
          ZI          RI          BLEN    NB      0.4998     0.0065     0.0834    2
NB            1          2          2          2          2          2
IMAT          1          1          1          1          1          1          1          1          1          1          1
TT=     1185.07    1149.75    1126.20    1095.51    1075.30    1047.42    1030.05    1004.21     989.85     968.79     957.45
XS=      0.5222     0.5212     0.5202     0.5192     0.5182     0.5172     0.5162     0.5152     0.5143     0.5133     0.5123
YS=      0.0082     0.0081     0.0080     0.0080     0.0079     0.0078     0.0077     0.0077     0.0076     0.0075     0.0074
FI=     0.13
          ZI          RI          BLEN    NB      0.4777     0.0079     0.0615    3
          ZI          RI          BLEN    NB      0.4663     0.0065     0.0501    2
          ZI          RI          BLEN    NB      0.4663     0.0065     0.0501    2
          ZI          RI          BLEN    NB      0.4663     0.0065     0.0501    2
          ZI          RI          BLEN    NB      0.4663     0.0065     0.0501    2
NB            1          3          2          2          2          2
IMAT          1          1          1          1          1          1          1          1          1          1          1
TT=     1184.95    1152.14    1127.69    1099.87    1080.13    1055.35    1038.49    1015.89    1000.63     979.91     965.04
XS=      0.5195     0.5185     0.5175     0.5165     0.5155     0.5145     0.5135     0.5125     0.5115     0.5105     0.5095
YS=      0.0134     0.0132     0.0131     0.0130     0.0129     0.0127     0.0126     0.0125     0.0123     0.0122     0.0121
FI=     0.19
          ZI          RI          BLEN    NB      0.4777     0.0120     0.0622    3
          ZI          RI          BLEN    NB      0.4495     0.0065     0.0335    2
          ZI          RI          BLEN    NB      0.4495     0.0065     0.0335    2
          ZI          RI          BLEN    NB      0.4495     0.0065     0.0335    2
          ZI          RI          BLEN    NB      0.4495     0.0065     0.0335    2
NB            1          3          2          2          2          2
IMAT          1          1          1          1          1          1          1          1          1          1          1
TT=     1184.08    1158.83    1142.34    1124.12    1101.26    1089.46    1067.74    1050.24    1038.15    1014.97    1001.98
XS=      0.5156     0.5146     0.5136     0.5126     0.5116     0.5107     0.5097     0.5087     0.5077     0.5067     0.5058
YS=      0.0195     0.0193     0.0191     0.0189     0.0187     0.0185     0.0183     0.0181     0.0179     0.0177     0.0175
FI=     0.28
          ZI          RI          BLEN    NB      0.4679     0.0145     0.0532    3
          ZI          RI          BLEN    NB      0.4335     0.0065     0.0238    2
          ZI          RI          BLEN    NB      0.4335     0.0065     0.0238    2
          ZI          RI          BLEN    NB      0.4335     0.0065     0.0235    2
          ZI          RI          BLEN    NB      0.4335     0.0065     0.0238    2
```

```
IMAT       1        1        1        1        1        1        1        1        1        1        1
TT=  1055.68  1034.92  1021.34  1011.66   992.31   980.36   971.47   953.50   941.53   934.36   918.27
XS=   0.5000   0.4990   0.4981   0.4971   0.4961   0.4952   0.4942   0.4933   0.4923   0.4913   0.4904
YS=   0.0235   0.0233   0.0230   0.0727   0.0224   0.0222   0.0219   0.0216   0.0214   0.0211   0.0208
FI=   0.42
        ZI         RI        BLEN    NB      0.4534    0.0165    0.0402    3
        ZI         RI        BLEN    NB      0.4367    0.0090    0.0219    2
        ZI         RI        BLEN    NB      0.4367    0.0090    0.0219    2
        ZI         RI        BLEN    NB      0.4367    0.0090    0.0219    2
        ZI         RI        BLEN    NB      0.4367    0.0090    0.0219    2
NB         1        3        2        2        2        2
IMAT       1        1        1        1        1        1        1        1        1        1        1
TT=   970.91   953.77   939.98   932.32   918.93   902.89   895.61   886.24   871.09   860.59   853.90
XS=   0.4792   0.4783   0.4774   0.4765   0.4756   0.4747   0.4738   0.4729   0.4720   0.4710   0.4701
YS=   0.0281   0.0277   0.0273   0.0269   0.0265   0.0261   0.0257   0.0253   0.0248   0.0244   0.0240
FI=   0.70
        ZI         RI        BLEN    NB      0.4387    0.0186    0.0288    3
        ZI         RI        BLEN    NB      0.4367    0.0169    0.0262    2
        ZI         RI        BLEN    NB      0.4367    0.0169    0.0262    2
        ZI         RI        BLEN    NB      0.4367    0.0169    0.0262    2
        ZI         RI        BLEN    NB      0.4367    0.0169    0.0262    2
NB         1        3        2        2        2        2
IMAT       1        1        1        1        1        1        1        1        1        1        1
TT=   882.46   865.39   855.20   845.43   830.59   824.74   812.58   800.84   794.95   780.46   772.50
XS=   0.4542   0.4534   0.4526   0.4519   0.4511   0.4503   0.4496   0.4488   0.4481   0.4473   0.4465
YS=   0.0316   0.0310   0.0304   0.0297   0.0291   0.0284   0.0278   0.0271   0.0265   0.0258   0.0252
FI=   1.34
        ZI         RI        BLEN    NB      0.4236    0.0298    0.0306    1
        ZI         RI        BLEN    NB      0.4228    0.0265    0.0272    2
        ZI         RI        BLEN    NB      0.4228    0.0265    0.0272    2
        ZI         RI        BLEN    NB      0.4228    0.0265    0.0272    2
        ZI         RI        BLEN    NB      0.4228    0.0265    0.0272    2
NB         2        1        2        2        2        2
IMAT       2        2        2        2        1        1        1        1        1        1        2
TT=   819.09   814.31   811.99   807.43   803.40   785.81   778.78   762.31   756.07   740.76   737.25
XS=   0.4250   0.4248   0.4245   0.4243   0.4241   0.4239   0.4236   0.4234   0.4232   0.4230   0.4227
YS=   0.0357   0.0348   0.0338   0.0328   0.0319   0.0309   0.0299   0.0289   0.0280   0.0270   0.0260
FI=   1.57
        ZI         RI        BLEN    NB      0.3333    0.0486    0.0486    2
        ZI         RI        BLEN    NB      0.3333    0.0486    0.0486    2
        ZI         RI        BLEN    NB      0.3333    0.0486    0.0486    2
        ZI         RI        BLEN    NB      0.3333    0.0486    0.0486    2
        ZI         RI        BLEN    NB      0.3333    0.0486    0.0486    2
NB         2        2        2        2        2        2
IMAT       2        2        2        2        2        2        2        2        2        2        2
TT=   718.44   713.73   711.88   707.30   705.57   701.11   699.49   695.13   693.64   689.38   688.01
XS=   0.3333   0.3333   0.3333   0.3333   0.3333   0.3333   0.3333   0.3333   0.3333   0.3333   0.3333
YS=   0.0486   0.0476   0.0466   0.0456   0.0446   0.0436   0.0426   0.0416   0.0406   0.0396   0.0386
FI=   1.57
        ZI         RI        BLEN    NB      0.2500    0.0603    0.0603    2
        ZI         RI        BLEN    NB      0.2500    0.0603    0.0603    2
        ZI         RI        BLEN    NB      0.2500    0.0603    0.0603    2
        ZI         RI        BLEN    NB      0.2500    0.0603    0.0603    2
        ZI         RI        BLEN    NB      0.2500    0.0603    0.0603    2
NB         2        2        2        2        2        2
IMAT       2        2        2        2        2        2        2        2        2        2        2
TT=   696.63   691.87   690.14   685.43   683.76   679.12   677.51   672.9[illegible]   671.3[illegible]   666.72   665.18
XS=   0.2500   0.2500   0.2500   0.2500   0.2500   0.2500   0.2500   0.2500   0.2500   0.2500   0.2500
YS=   0.0603   0.0593   0.0583   0.0573   0.0563   0.0553   0.0543   0.0533   0.0523   0.0513   0.0503
FI=   1.57
        ZI         RI        BLEN    NB      0.1250    0.0779    0.0779    2
        ZI         RI        BLEN    NB      0.1250    0.0779    0.0779    2
        ZI         RI        BLEN    NB      0.1250    0.0779    0.0779    2
        ZI         RI        BLEN    NB      0.1250    0.0779    0.0779    2
        ZI         RI        BLEN    NB      0.1250    0.0779    0.0779    [illegible]
```

```
NB         2       2       2       2       2       2
IMAT       2       2       2       2       2       2       2       2       2       2       2
TT=   686.79  682.23  680.58  676.07  674.47  669.95  668.37  663.76  662.19  657.49  655.93
XS=   0 1250  0 1250  0 1250  0 1250  0 1250  0 1250  0 1250  0 1250  0 1250  0 1250  0 1250
YS=   0.0779  0 0769  0 0759  0 0749  0 0739  0 0729  0 0719  0.0709  0.0699  0 0689  0 0679
FI=    1.57
        ZI        RI        BLEN    NB      0 0000    0 0955    0 0955    2
        ZI        RI        BLEN    NB      0 0000    0 0955    0 0955    2
        ZI        RI        BLEN    NB      0 0000    0 0955    0 0955    2
        ZI        RI        BLEN    NB      0 0000    0 0955    0 0955    2
        ZI        RI        BLEN    NB      0 0000    0 0955    0 0955    2
NB         2       2       2       2       2       2
IMAT       2       2       2       2       2       2       2       2       2       2       2
TT=   686 39  682 07  680 45  676 20  674 65  670 43  668 93  664 67  653 21  658 89  657 47
XS=   0 0000  0 0000  0 0000  0 0000  0 0000  0 0000  0 0000  0 0000  0 0000  0 0000  0 0000
YS=   0 0955  0 0945  0 0935  0 0925  0 0915  0 0905  0 0895  0 0885  0 0875  0 0865  0 0855

FLAGGED SURFACE POINTS HAVE BEEN DROPPED

0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
```

BRL IMPROVED ABRES SHA E CHANGE CODE (BRLASCC)

TIME = 0.4382 SEC SAMPLE PAGE 63

SUMMARY
****

ENVIRONMENT NO	SHAPE NO	TIME SEC
(NT)	(MT)	(TIMEP)
8	127	0.4382

FREESTREAM MACH NO	FREESTREAM UNIT RE NO 1/FT	STAGNATION PT ENTHALPY BTU/LBM	STAGNATION PT PRESSURE ATM	ISENTROPIC EXPONENT BEHIND SHOCK	NOSE RADIUS INCH	INVISCID SONIC STREAM LENGTH INCH
(AMACH)	(URI)	(HT[illegible])	(PT2)	(GAM2)	(RN)	(SSONIC)
4 51	3 1843E+07	510 4	26 968	1 313	0 2854	0.2120

-----STAGNATION POINT-----

SURFACE TEMPERATURE DEG R	RECESSION INCH	HEAT TRANSFER COEFFICIENT LBM/FT2-SEC	CURVED SHOCK HEAT TRANSFER AUG	TRANS PROXIMITY HEAT TRANSFER AUG	ROUGHNESS HEIGHT MIL
(TSTAGP)	(ZSTAGP)	(RUCH(1))	(HETAUG)	(RUFSMT(1))	(RUF(1))
1185 2	0 2602	5 0617	1 0031	3 7115	10 0000

NOSETIP DRAG COEF NORM BY RNI**2	SONIC STREAM LENGTH INCH	SONIC UNIT REYNOLDS NO 1/FT	AXIAL RECESSION AT R = 0 24 INCH INCH	TRANSITION STREAM LENGTH INCH
(CDRAG)	(SSTR)	(URESTR)	(ZSIDE)	(STRAN)
1 934	0 2142	1 9462E+07	0 0291	[illegible]378E-01

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.4382 SEC

- - - - - - - - - - - - - - - CONDUCTION TIME STEPS COMPUTED - - - - - - - - - - - - - - -

SHAPE NO	TIME (SEC)	STAG PT RECESS (INCH)	STAG PT REC RATE (IN/SEC)	STAG PT TEMP (DEG F)	TIME STEP USED (SEC)	NEXT SPEC PRINT TIME (SEC)	EXPLICIT STABILITY (SEC)	HEAT FLUX CHANGE (SEC)	SURF TEMP CHANGE (SEC)	LAT COND STABILITY (SEC)	HALF IMPLICIT NODE THICKNESS (SEC)
128	0.44	0.715	1.659E+00	1185.1	2.643E-03	6.182E-02	3.921E-03	5.308E-03	8.416E-02	1.183E-02	2.127E-02
129	0.44	0.717	4.238E-01	1185.1	3.392E-03	5.918E-02	3.921E-03	3.392E-03	6.498E-02	1.158E-02	2.168E-02
130	0.45	0.719	4.751E-01	1185.1	3.921E-03	5.579E-02	3.921E-03	4.353E-03	8.910E-01	1.157E-02	2.178E-02
131	0.45	0.721	5.672E-01	1185.1	3.921E-03	5.187E-02	3.921E-03	5.031E-03	8.928E-01	1.156E-02	2.172E-02
132	0.46	0.723	5.709E-01	1185.1	3.921E-03	4.795E-02	3.921E-03	5.032E-03	1.540E-01	1.152E-02	2.180E-02
133	0.46	0.725	5.695E-01	1185.1	3.921E-03	4.403E-02	3.921E-03	5.031E-03	1.585E-01	1.149E-02	2.181E-02
134	0.46	0.728	5.707E-01	1185.1	3.921E-03	4.011E-02	3.921E-03	5.031E-03	1.624E-01	1.145E-02	2.185E-02
135	0.47	0.730	5.708E-01	1185.1	3.921E-03	3.618E-02	3.921E-03	5.032E-03	1.638E-01	1.141E-02	2.189E-02
136	0.47	0.732	5.709E-01	1185.1	3.921E-03	3.226E-02	3.921E-03	5.031E-03	1.639E-01	1.138E-02	2.193E-02
137	0.48	0.734	5.709E-01	1185.1	3.921E-03	2.834E-02	3.921E-03	5.032E-03	1.634E-01	1.134E-02	2.199E-02
138	0.48	0.737	5.704E-01	1185.1	3.921E-03	2.442E-02	3.921E-03	5.031E-03	1.625E-01	1.130E-02	2.204E-02
139	0.48	0.739	5.699E-01	1185.1	3.921E-03	2.050E-02	3.921E-03	5.032E-03	1.616E-01	1.126E-02	2.209E-02
140	0.49	0.741	5.695E-01	1185.1	3.921E-03	1.658E-02	3.921E-03	5.032E-03	1.608E-01	1.122E-02	2.213E-02
141	0.49	0.743	5.694E-01	1185.1	3.921E-03	1.266E-02	3.921E-03	5.032E-03	1.570E-01	1.118E-02	2.216E-02
142	0.50	0.745	5.695E-01	1185.1	3.921E-03	8.740E-03	3.921E-03	5.032E-03	1.538E-01	1.115E-02	2.222E-02
143	0.50	0.748	5.687E-01	1185.1	3.921E-03	4.819E-03	3.921E-03	5.032E-03	1.512E-01	1.111E-02	2.226E-02
144	0.50	0.750	2.480E+00	1185.1	8.983E-04	8.983E-04	3.921E-03	5.032E-03	1.491E-01	1.107E-02	2.233E-02

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.5000 SEC　　SAMPLE PAGE 65

TEMPERATURES IN SURFACE LAYER,DEG R (TT)

	SURFACE MATERIAL INDEX	1	2	3	4	5	6	7	8	9	10	11
1	1	1185.1	1147.7	1108.9	1076.3	1049.5	1025.1	1018.5	1004.5	997.7	980.8	974.5
2	1	1185.0	1153.1	1130.3	1101.7	1083.1	1057.3	1042.9	1019.9	1009.2	986.5	978.9
3	1	1184.9	1152.0	1127.6	1099.7	1080.8	1056.0	1041.5	1018.4	1007.7	985.7	979.2
4	1	1184.8	1156.7	1138.6	1112.4	1097.5	1072.2	1059.8	1034.7	1024.4	999.2	991.1
5	1	1066.4	1044.2	1035.8	1014.4	1006.7	986.1	979.0	959.1	952.4	933.3	927.1
6	1	982.5	964.6	958.2	940.6	934.5	917.4	911.5	894.8	889.2	873.1	867.9
7	1	896.6	878.9	872.6	855.7	849.3	833.9	828.6	813.1	807.9	792.7	787.8
8	2	823.2	818.5	816.4	811.8	809.8	805.4	803.6	787.5	781.4	764.9	761.6
9	2	727.4	723.2	721.4	717.3	715.7	711.7	710.2	706.4	705.0	701.3	700.3
10	2	702.9	698.3	696.6	692.1	690.5	686.0	684.5	680.0	678.5	674.2	672.9
11	2	691.7	687.3	685.7	681.3	679.8	675.4	673.9	669.5	668.0	663.6	662.2
12	2	692.3	688.0	686.4	682.1	680.6	676.4	674.9	670.8	669.4	665.3	664.0

SURFACE LAYER NODELET MATERIAL INDICES (IMAT)

	1	2	3	4	5	6	7	8	9	10	11
1	1	1	1	1	1	2	2	2	2	2	2
2	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1
8	2	2	2	2	2	2	2	1	1	1	2
9	2	2	2	2	2	2	2	2	2	2	2
10	2	2	2	2	2	2	2	2	2	2	2
11	2	2	2	2	2	2	2	2	2	2	2
12	2	2	2	2	2	2	2	2	2	2	2

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

SAMPLE

TIME = 0.5000 SEC PAGE 66

INTERNAL EXPLICIT NODE FLAGS (NREG)

	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
22	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
21	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0
20	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0
19	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	1	1	1
18	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	1	1	1	1	1	1
17	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
16	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
15	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	2	2	2	2	2	2	2	2	2	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	2	2	2	2	2	2	2	2	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	2	2	2	2	2	2	2	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	2	2	2	2	2	2	2	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	2	2	2	2	2	2	2	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

INTERNAL EXPLICIT NODE MATERIAL INDICES (NMAT)

	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
22	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
21	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
20	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
19	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
18	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
17	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
16	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
15	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
14	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
13	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
12	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
11	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

SAMPLE
TIME = 0.5000 SEC PAGE 67

TEMPERATURES IN INTERNAL EXPLICIT GRID,DEG R (T)

	60	56	52	48	44	40	36	32	28	24	20	16	12	8	4
	59	55	51	47	43	39	35	31	27	23	19	15	11	7	3
	58	54	50	46	42	38	34	30	26	22	18	14	10	6	2
	57	53	49	45	41	37	33	29	25	21	17	13	9	5	1
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	687.8
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	684.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	680.9
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	679.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	391.7	675.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	687.0	676.7
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	682.5	667.8
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	681.3	665.7
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	677.4	665.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	689.8	674.4	662.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	686.2	669.8	660.2
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	684.6	668.9	657.2
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	680.4	664.2	655.6
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	675.6	664.2	653.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	687.8	672.4	660.7	651.9
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	688.9	670.3	659.7	648.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	683.8	667.2	655.9	646.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	679.7	663.2	654.4	644.2
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	674.7	662.7	651.4	643.4
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	695.8	676.0	661.6	650.4	639.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	690.8	670.2	658.4	647.2	637.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	684.9	665.4	654.9	645.1	635.6
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	680.4	665.1	653.2	642.3	635.1
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	681.1	666.0	652.6	641.4	631.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	696.6	677.0	661.7	649.5	638.5	629.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	692.3	672.1	657.5	646.3	636.2	627.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	686.7	666.3	655.8	644.1	633.6	627.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	688.6	668.2	656.6	643.8	632.9	623.2
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	682.7	667.2	652.8	640.8	630.2	621.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	697.8	677.7	663.2	649.2	637.8	627.9	619.9
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	693.0	673.7	658.5	646.8	635.5	625.5	619.6
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	697.3	674.3	660.2	647.6	635.4	624.9	616.0

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

```
                                                                                       SAMPLE
                                                                  TIME =   0.5000 SEC   PAGE  68
      0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0  691.0  670.2  657.9  644.2  632.5  622.4  514.3
        0.0    0.0    0.0    0.0    0.0    0.0    0.0  712.8  684.6  668.3  654.2  640.8  629.7  620.2  613.0
          0.0    0.0    0.0    0.0    0.0    0.0    0.0  705.3  678.8  664.7  650.2  638.2  627.3  618.0  612.8

12    0.0    0.0    0.0    0.0    0.0    0.0    0.0  713.4  684.5  665.9  651.7  639.0  627.4  617.5  609.5
        0.0    0.0    0.0    0.0    0.0    0.0    0.0  705.5  676.7  662.0  648.9  635.8  624.7  615.3  608.0
          0.0    0.0    0.0    0.0    0.0    0.0    0.0  698.2  674.9  659.2  645.4  632.7  622.1  613.3  606.9
            0.0    0.0    0.0    0.0    0.0    0.0  719.7  692.9  670.1  655.7  641.8  630.1  619.8  611.3  606.8

11    0.0    0.0    0.0    0.0    0.0    0.0  736.2  699.5  675.5  657.3  643.3  630.9  620.0  611.0  604.0
        0.0    0.0    0.0    0.0    0.0    0.6  722.5  693.4  669.1  653.4  640.3  627.9  617.5  609.0  602.7
          0.0    0.0    0.0    0.0    0.0    0.0  713.8  685.7  665.8  650.4  637.0  625.1  615.2  607.2  601.8
            0.0    0.0    0.0    0.0    0.0    0.0  706.2  681.9  661.4  646.9  633.7  622.5  613.1  605.5  601.7

10    0.0    0.0    0.0    0.0    0.0  781.6  733.8  689.7  666.7  648.8  635.2  623.3  613.3  605.3  599.3
        0.0    0.0    0.0    0.0    0.0  766.4  708.8  683.7  661.0  645.1  632.2  620.6  611.1  603.6  598.3
          0.0    0.0    0.0    0.0    0.0  751.6  701.3  677.1  657.1  641.9  629.1  618.0  609.0  602.1  597.5
            0.0    0.0    0.0    0.0    0.0  738.1  694.9  672.3  652.9  638.6  626.1  615.6  607.1  600.6  597.5

 9    0.0    0.0    0.0    0.0    0.0  767.2  712.2  680.2  658.2  640.7  627.6  616.5  607.5  600.6  595.6
        0.0    0.0    0.0    0.0  810.8  753.8  700.4  674.4  652.9  637.1  624.7  614.0  605.6  599.1  594.8
          0.0    0.0    0.0    0.0  796.5  734.3  692.5  668.5  648.8  633.9  621.8  611.7  603.7  597.8  594.2
            0.0    0.0    0.0    0.0  781.3  718.7  685.9  663.5  644.7  630.7  619.1  609.5  602.1  596.6  594.1

 8    0.0    0.0    0.0    0.0  811.7  737.9  701.9  671.5  650.0  633.1  620.6  610.5  602.5  596.7  592.7
        0.0    0.0    0.0    0.0  796.3  738.3  691.7  665.9  645.1  629.6  617.9  608.3  600.9  595.5  592.0
          0.0    0.0    0.0  860.4  778.9  723.9  683.8  660.3  640.9  626.5  615.3  606.2  599.3  594.5  591.6
            0.0    0.0    0.0  832.8  758.6  710.4  677.3  655.2  636.9  623.5  612.8  604.3  598.0  593.5  591.5

 7    0.0    0.0    0.0  892.7  777.4  730.9  692.8  663.6  642.4  626.1  614.4  605.3  598.5  593.6  590.5
        0.0    0.0    0.0  846.5  757.6  725.6  683.6  658.0  637.7  622.8  611.9  603.4  597.1  592.7  590.0
          0.0    0.0    0.0  810.5  761.4  713.7  675.9  652.4  633.6  619.9  609.6  601.6  595.8  591.9  589.6
            0.0    0.0  943.1  795.3  746.9  701.8  669.4  647.4  629.7  617.1  607.3  600.0  594.7  591.1  589.6

 6    0.0    0.0    0.0  839.5  753.0  722.7  684.9  656.3  635.4  619.9  609.1  601.0  595.2  591.3  588.9
        0.0    0.0 1000.5  799.3  748.0  715.2  676.3  650.6  631.0  616.9  606.8  599.3  594.1  590.6  588.5
          0.0    0.0  928.8  772.4  747.0  704.7  668.8  645.2  627.0  614.1  604.7  597.8  593.1  589.9  588.2
            0.0    0.0  886.2  755.4  735.7  693.9  662.2  640.2  623.3  611.5  602.8  596.5  592.1  589.4  588.2

 5    0.0    0.0 1021.9  792.9  741.7  715.1  678.3  649.8  629.3  614.7  604.7  597.6  592.8  589.6  587.8
        0.0    0.0  946.0  758.4  738.2  706.8  670.0  644.1  625.1  611.8  602.7  596.2  591.8  589.1  587.5
          0.0    0.0  883.1  725.2  735.4  697.0  662.5  638.8  621.3  609.2  600.8  594.9  591.0  588.6  587.3
            0.0    0.0  838.2  742.5  726.1  687.1  655.8  634.0  617.8  606.8  599.1  593.8  590.3  588.1  587.3

 4    0.0    0.0  981.2  741.2  732.3  708.6  672.9  644.3  624.3  610.4  601.2  595.0  591.0  588.4  587.0
        0.0    0.0  900.2  700.7  730.0  700.1  664.8  638.7  620.3  607.7  599.5  593.8  590.2  588.0  586.8
          0.0    0.0  842.7  680.2  726.5  690.9  657.2  633.5  616.6  605.3  597.8  592.8  589.5  587.6  586.6
            0.0 1129.2  801.7  731.2  718.4  681.5  650.4  628.7  613.4  603.2  596.4  591.8  589.0  587.3  586.6

 3    0.0    0.0  946.1  691.8  725.1  703.7  668.8  640.1  620.5  607.2  598.8  593.3  589.8  587.7  586.5
        0.0    0.0  867.6  663.9  723.7  695.3  660.6  634.5  616.6  604.8  597.2  592.2  589.1  587.3  586.3
          0.0    0.0  810.7  661.2  720.0  686.3  653.0  629.4  613.2  602.5  595.7  591.3  588.6  587.0  586.2
            0.0 1070.1  742.9  721.8  712.7  677.3  646.2  624.8  610.0  600.6  594.4  590.5  588.1  586.7  586.2
```

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.5000 SEC   SAMPLE PAGE 69

```
2    0.0    0.0  932.7  689.5  720.2  700.6  666.2  637.3  618.1  605.3  597.3  592.2  589.1  587.2  586.2
       0.0    0.0  855.7  668.0  719.6  692.2  657.9  631.8  614.3  602.9  595.8  591.3  588.5  586.9  586.1
         0.0    0.0  794.8  673.3  716.0  683.5  650.3  626.8  610.9  600.8  594.4  590.4  588.0  586.6  586.0
           0.0 1033.7  732.9  713.1  709.1  674.7  643.4  622.2  608.0  598.9  593.2  589.7  587.6  586.4  586.0

1    0.0    0.0  932.1  690.4  719.6  700.4  666.0  637.1  617.8  605.0  597.0  592.0  589.0  587.2  586.2
       0.0    0.0  856.1  669.3  719.3  692.0  657.8  631.5  614.0  602.6  595.6  591.1  588.4  586.9  586.0
         0.0    0.0  794.5  674.8  715.7  683.3  650.1  626.5  610.7  600.5  594.2  590.3  587.9  586.6  585.9
           0.0 1005.8  733.6  711.4  708.8  674.5  643.2  621.9  607.7  598.7  593.1  589.6  587.5  586.4  585.9
```

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.5000 SEC   SAMPLE PAGE 70

BODY POINT LOCATION AND SURFACE ENERGY BALANCE RESULTS
****

BODY PT NO (J)	AXIAL LENGTH INCH (ZSP)	RADIAL LENGTH INCH (RSP)	SURFACE TEMP DEG R (TSP)	TOTAL RECESS RATE IN/SEC (SDOT)	EROSION RECESS RATE IN/SEC (SDOTE)	B-PRIME THERMOCHEM (BPSP)	EROSION MASS LOSS RATE LBM/SEC-FT2 (EMDOT)	HEAT TRANS COEFFICIENT LBM/FT2-SEC (RUCHSP)	RECOVERY ENTHALPY BTU/LBM (HRSP)	SURFACE PRESSURE ATM (PRESP)
1	0.7499	0.0000	1185.1	2.4798*	0.0000	3.375E-04*	0.0000	5.011E+00	501.8	26.5162
2	0.7685	0.0956	1185.0	0.5375	0.0000	0.000E+00	0.0000	4.621E+00	499.3	23.0771
3	0.8020	0.1559	1184.9	0.5191	0.0000	0.000E+00	0.0000	4.815E+00	495.8	19.1073
4	0.8419	0.2279	1184.8	0.3778	0.0000	0.000E+00	0.0000	3.684E+00	485.3	9.9063
5	1.0000	0.2823	1066.4	0.0000	0.0000	9.441E-04	0.0000	9.588E-01	469.1	2.7056
6	1.2490	0.3375	982.5	0.0000	0.0000	6.618E-04	0.0000	7.534E-01	466.3	2.0607
7	1.5500	0.3798	896.6	0.0000	0.0000	4.598E-04	0.0000	6.243E-01	464.3	1.6873
8	1.9000	0.4290	823.2	0.0000	0.0000	3.370E-04	0.0000	6.095E-01	463.5	1.6028
9	3.0000	0.5836	727.4	0.0000	0.0000	2.245E-04	0.0000	5.445E-01	462.1	1.4750
10	4.0000	0.7241	702.9	0.0000	0.0000	2.024E-04	0.0000	5.503E-01	461.1	1.4446
11	5.5000	0.9349	691.7	0.0000	0.0000	1.931E-04	0.0000	5.253E-01	459.5	1.4268
12	7.0000	1.1458	692.3	0.0000	0.0000	1.935E-04	0.0000	5.220E-01	454.9	1.4212

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.5000 SEC SAMPLE PAGE 71

SUMMARY
****

ENVIRONMENT NO	SHAPE NO	TIME SEC
(NT)	(MT)	(TIMEP)
9	144	0.5000

FREESTREAM MACH NO	FREESTREAM UNIT RE NO 1/FT	STAGNATION PT ENTHALPY BTU/LBM	STAGNATION PT PRESSURE ATM	ISENTROPIC EXPONENT BEHIND SHOCK	NOSE RADIUS INCH	INVISCID SONIC STREAM LENGTH INCH
(AMACH)	(UR1)	(HT2)	(PT2)	(GAM2)	(RN)	(SSONIC)
4.47	3.1568E+07	501.7	26.514	1.314	0.2886	0.2135

STAGNATION POINT

SURFACE TEMPERATURE DEG R	RECESSION INCH	HEAT TRANSFER COEFFICIENT LBM/FT2-SEC	CURVED SHOCK HEAT TRANSFER AUG	TRANS PROXIMITY HEAT TRANSFER AUG	ROUGHNESS HEIGHT MIL
(TSTAGP)	(ZSTAGP)	(RUCH(1))	(HETAUG)	(RUFSMT(1))	(RUF(1))
1185.1	0.2992	5.0296	1.0032	3.7143	10.0000

NOSETIP DRAG COEF NORM BY RN1**2	SONIC STREAM LENGTH INCH	SONIC UNIT REYNOLDS NO 1/FT	AXIAL RECESSION AT R = 0.24 INCH INCH	TRANSITION STREAM LENGTH INCH
(CDRAG)	(SSTR)	(URESTR)	(ZSIDE)	(STRAN)
1.994	0.2162	1.9288E+07	0.0687	417E-01

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.5000 SEC SAMPLE PAGE 77

- - - - - - - - - - - - - - - CONDUCTION TIME STEPS COMPUTED - - - - - - - - - - - - - - -

SHAPE NO	TIME (SEC)	STAG PT RECESS (INCH)	STAG PT REC RATE (IN/SEC)	STAG PT TEMP (DEG R)	TIME STEP USED (SEC)	NEXT SPEC PRINT TIME (SEC)	EXPLICIT STABILITY (SEC)	HEAT FLUX CHANGE (SEC)	SURF TEMP CHANGE (SEC)	LAT COND STABILITY (SEC)	HALF IMPLICIT NODE THICKNESS (SEC)
145	0.50	0.751	6.023E-01	1185.0	1.229E-03	2.500E-01	3.921E-03	1.229E-03	5.510E-02	1.094E-02	2.347E-02
146	0.50	0.751	4.173E-01	1185.1	1.577E-03	2.488E-01	3.921E-03	1.577E-03	1.943E-02	1.092E-02	2.303E-02
147	0.50	0.752	4.295E-01	1185.1	2.024E-03	2.472E-01	3.921E-03	2.024E-03	3.139E-02	1.092E-02	2.285E-02
148	0.51	0.753	4.346E-01	1185.1	2.598E-03	2.452E-01	3.921E-03	2.598E-03	4.186E-02	1.092E-02	2.285E-02
149	0.51	0.755	4.345E-01	1185.1	3.334E-03	2.426E-01	3.921E-03	3.334E-03	5.139E-02	1.092E-02	2.291E-02
150	0.51	0.757	4.729E-01	1185.1	3.921E-03	2.392E-01	3.921E-03	4.279E-03	6.065E-02	1.091E-02	2.293E-02
151	0.52	0.759	5.564E-01	1185.1	3.921E-03	2.353E-01	3.921E-03	5.032E-03	6.814E-02	2.450E-02	2.297E-02
152	0.52	0.761	5.552E-01	1185.1	3.921E-03	2.314E-01	3.921E-03	5.032E-03	7.182E-02	2.441E-02	2.299E-02
153	0.53	0.763	5.549E-01	1185.1	3.921E-03	2.275E-01	3.921E-03	5.031E-03	7.454E-02	2.431E-02	2.299E-02
154	0.53	0.765	5.554E-01	1185.1	3.921E-03	2.236E-01	3.921E-03	5.032E-03	7.668E-02	2.422E-02	2.298E-02
155	0.53	0.768	5.561E-01	1185.1	3.921E-03	2.196E-01	3.921E-03	5.031E-03	7.836E-02	2.413E-02	2.299E-02
156	0.54	0.770	5.551E-01	1185.1	3.921E-03	2.157E-01	3.921E-03	5.032E-03	7.972E-02	2.402E-02	2.301E-02
157	0.54	0.772	5.548E-01	1185.1	3.921E-03	2.118E-01	3.921E-03	5.031E-03	8.083E-02	2.390E-02	2.303E-02
158	0.55	0.774	5.544E-01	1185.1	3.921E-03	2.079E-01	3.921E-03	5.032E-03	8.134E-02	2.378E-02	2.305E-02
159	0.55	0.776	5.545E-01	1185.1	3.921E-03	2.040E-01	3.921E-03	5.032E-03	8.236E-02	2.367E-02	2.305E-02
160	0.55	0.778	5.551E-01	1185.1	3.921E-03	2.000E-01	3.921E-03	5.032E-03	8.340E-02	2.355E-02	2.308E-02
161	0.56	0.781	5.546E-01	1185.1	3.921E-03	1.961E-01	3.921E-03	5.031E-03	8.429E-02	2.344E-02	2.310E-02
162	0.56	0.783	5.548E-01	1185.1	3.921E-03	1.922E-01	3.921E-03	5.032E-03	8.507E-02	2.333E-02	2.304E-02
163	0.57	0.785	5.574E-01	1185.1	3.921E-03	1.883E-01	3.921E-03	5.032E-03	8.578E-02	2.323E-02	2.300E-02
164	0.57	0.787	5.596E-01	1185.2	3.921E-03	1.843E-01	3.921E-03	5.032E-03	8.640E-02	2.312E-02	2.296E-02
165	0.57	0.789	5.615E-01	1185.2	3.921E-03	1.804E-01	3.921E-03	5.032E-03	8.696E-02	2.301E-02	2.293E-02
166	0.58	0.792	5.631E-01	1185.2	3.921E-03	1.765E-01	3.921E-03	5.032E-03	8.745E-02	2.290E-02	2.295E-02
167	0.58	0.794	5.631E-01	1185.2	3.921E-03	1.726E-01	3.921E-03	5.031E-03	8.789E-02	2.279E-02	2.296E-02
168	0.59	0.796	5.631E-01	1185.2	3.921E-03	1.687E-01	3.921E-03	5.032E-03	8.827E-02	2.269E-02	2.295E-02
169	0.59	0.798	5.641E-01	1185.2	3.921E-03	1.647E-01	3.921E-03	5.032E-03	8.860E-02	2.258E-02	2.291E-02
170	0.59	0.800	5.659E-01	1185.2	3.921E-03	1.608E-01	3.921E-03	5.032E-03	8.889E-02	2.247E-02	2.283E-02
171	0.60	0.803	5.693E-01	1185.2	3.921E-03	1.569E-01	3.921E-03	5.032E-03	8.915E-02	2.236E-02	2.276E-02
172	0.60	0.805	5.721E-01	1185.2	3.921E-03	1.530E-01	3.921E-03	5.032E-03	8.938E-02	2.225E-02	2.268E-02
173	0.60	0.807	5.754E-01	1185.2	3.921E-03	1.491E-01	3.921E-03	5.032E-03	8.958E-02	2.214E-02	2.259E-02
174	0.61	0.809	5.792E-01	1185.2	3.921E-03	1.451E-01	3.921E-03	5.032E-03	8.977E-02	2.203E-02	2.255E-02
175	0.61	0.812	5.807E-01	1185.2	3.921E-03	1.412E-01	3.921E-03	5.032E-03	9.000E-02	2.192E-02	2.255E-02
176	0.62	0.814	5.810E-01	1185.2	3.921E-03	1.373E-01	3.921E-03	5.032E-03	9.021E-02	2.181E-02	2.257E-02
177	0.62	0.816	5.806E-01	1185.2	3.921E-03	1.334E-01	3.921E-03	5.031E-03	9.041E-02	2.169E-02	2.261E-02
178	0.62	0.819	5.796E-01	1185.2	3.921E-03	1.295E-01	3.921E-03	5.031E-03	9.058E-02	2.158E-02	2.265E-02
179	0.63	0.821	5.784E-01	1185.2	3.921E-03	1.255E-01	3.921E-03	5.032E-03	9.075E-02	2.147E-02	2.269E-02
180	0.63	0.823	5.769E-01	1185.2	3.921E-03	1.216E-01	3.921E-03	5.031E-03	9.091E-02	2.136E-02	2.275E-02
181	0.64	0.825	5.753E-01	1185.2	3.921E-03	1.177E-01	3.921E-03	5.032E-03	9.108E-02	2.125E-02	2.279E-02

BODY SLOPE BEFORE POINT 5 HAS CHANGED BY A FACTOR OF 2.0 ----- COMPUTE NEW ENVIRONMENT

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.6362 SEC   SAMPLE PAGE 78

BODY POINT LOCATION AND SURFACE ENERGY BALANCE RESULTS

BODY PT NO (J)	AXIAL LENGTH INCH (ZSP)	RADIAL LENGTH INCH (RSP)	SURFACE TEMP DEG R (TSP)	TOTAL RECESS RATE IN/SEC (SDOT)	EROSION RECESS RATE IN/SEC (SDOTE)	B-PRIME THERMOCHEM (BPSP)	EROSION MASS LOSS RATE LBM/SEC-FT2 (EMDOT)	HEAT TRANS COEFFICIENT LBM/FT2-SEC (RUCHSP)	RECOVERY ENTHALPY BTU/LBM (HRSP)	SURFACE PRESSURE ATM (PRESP)
1	0.8253	0.0000	1185.2	0.5753•	0.0000	3.375E-04•	0.0000	4.914E+00	482.4	25.4961
2	0.8431	0.0898	1185.1	0.5265	0.0000	0.000E+00	0.0000	4.437E+00	480.0	22.3520
3	0.8723	0.1467	1184.8	0.4737	0.0000	0.000E+00	0.0000	4.576E+00	477.1	18.9168
4	0.9037	0.2157	1184.8	0.3940	0.0000	0.000E+00	0.0000	3.827E+00	468.0	10.6435
5	1.0000	0.2823	1160.4	0.0002	0.0000	6.469E-03	0.0000	1.198E+00	452.3	3.0014
6	1.2490	0.3375	1028.2	0.0000	0.0000	8.031E-04	0.0000	7.732E-01	448.1	1.9982
7	1.5500	0.3798	931.9	0.0000	0.0000	5.340E-04	0.0000	6.372E-01	446.0	1.6332
8	1.9000	0.4290	854.6	0.0000	0.0000	3.850E-04	0.0000	6.180E-01	445.3	1.5562
9	3.0000	0.5836	753.1	0.0000	0.0000	2.504E-04	0.0000	5.660E-01	444.1	1.4373
10	4.0000	0.7241	717.3	0.0000	0.0000	2.152E-04	0.0000	5.396E-01	443.2	1.4085
11	5.5000	0.9349	701.6	0.0000	0.0000	2.013E-04	0.0000	5.150E-01	441.6	1.3922
12	7.0000	1.1458	702.7	0.0000	0.0000	2.023E-04	0.0000	5.125E-01	436.3	1.3867

BRL IMPROVED ABRES SHAPE CHANGE CODE (BRLASCC)

TIME = 0.6362 SEC

SAMPLE
PAGE 79

SUMMARY
****

ENVIRONMENT NO	SHAPE NO	TIME SEC
(NT)	(MT)	(TIMEP)
10	181	0.6362

FREESTREAM MACH NO	FREESTREAM UNIT RE NO 1/FT	STAGNATION PT ENTHALPY BTU/LBM	STAGNATION PT PRESSURE ATM	ISENTROPIC EXPONENT BEHIND SHOCK	NOSE RADIUS INCH	INVISCID SONIC STREAM LENGTH INCH
(AMACH)	(URI)	(HT2)	(PT2)	(GAM2)	(RN)	(SSONIC)
4.39	3.0955E+07	482.4	25.478	1.316	0.3212	0.2364

STAGNATION POINT					
SURFACE TEMPERATURE DEG R	RECESSION INCH	HEAT TRANSFER COEFFICIENT LBM/FT2-SEC	CURVED SHOCK HEAT TRANSFER AUG	TRANS PROXIMITY HEAT TRANSFER AUG	ROUGHNESS HEIGHT MIL
(TSTAGP)	(ZSTAGP)	(RUCH(1))	(HETAUG)	(RUFSMT(1))	(RUF(1))
1185.2	0.3746	4.9272	1.0032	3.7179	10.0000

NOSETIP DRAG COEF NORM BY RNI**2	SONIC STREAM LENGTH INCH	SONIC UNIT REYNOLDS NO 1/FT	AXIAL RECESSION AT R = 0.24 INCH INCH	TRANSITION STREAM LENGTH INCH
(CDRAG)	(SSTR)	(URESTR)	(ZSIDE)	(STRAN)
2.280	0.2410	1.9148E+07	0.1310	392E-01

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2. Sandhu, S.S., and A. L. Murray, "Improved Capabilities of the ABRES Shape Change Code (ASCC79)," Reentry Vehicle Technology (REV-TECH) Program Interim Report, Volume III, Acurex Report TR-79-10/AS, July 1979.

3. Murray, A.L., and J. L. Saperstein, "User's Manual for the Updated ABRES Shape Change Code (ASCC80)," Reentry Vehicle Technology (REV-TECH) Program Final Report, Volume III, Part I, Acurex Report FR-80-38/AS, October 1980.

4. Carslaw, H.S., and J. C. Jaeger, "*Conduction of Heat in Solids*," Second edition, Oxford: Oxford University Press, 1959.

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